PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR

PROMOTING USEFUL KNOWLEDGE

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VOL. XI. 1869. No. 81.

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PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

VOL. XI. JANUARY, 1869. No. 81.

Stated Meeting, January 1, 1869.

Present, three members.

Mr. ELI K. PRICE, in the Chair.

A letter accepting membership was received from John Tyndall, dated London, May 21, 1868.

A request from Prof. Dawson for a set of the Transactions for the Montreal Natural History Society, was referred to the Committee of Publication.

The Surgeon General's Office, at Washington, was ordered to be placed on the list of correspondents to receive the Proceedings.

Donations for the Library were received from the Prussian Academy, Bureau des Ponts, Royal Astronomical and Geological Societies, Boston Natural History Society, Renselaer Polytechnic Institute, Franklin Institute, and Dr. Newberry.

The report of the Judges and Clerks of the Annual Election for Officers of the Society held this day, was read, an-

nouncing that the following named members were elected Officers for the ensuing year:

President.

George B. Wood.

Vice-Presidents.

John C. Cresson,
Isaac Lea,
Frederick Fraley.

Secretaries.

Charles B. Trego,
E. Otis Kendall,
John L. Le Conte,
J. P. Lesley.

Curators.

Franklin Peale,
Elias Durand,
Joseph Carson.

Treasurer.

Charles B. Trego.

Counsellors.

Frederick Fraley,
Robert Patterson,
Daniel R. Goodwin,
E. K. Price.

Pending nominations, Nos. 593 to 621 were read.
And the Society was adjourned.

Stated Meeting, January 15, 1869.

Present, ten members.

JOHN C. CRESSON, Vice-President, in the Chair.

Letters of acknowledgment were received from the Society of Emulation of Abbeville and the Royal Institution.

Letters of envoi were received from the Meteorological Office of the Royal Society, and from the Society of Physical and Natural Sciences at Bordeaux, requesting an exchange of publications, which was referred to the Secretaries with power to act.

A request for the loan of Mariana's History of Spain for six months from President Coppée, was referred to the Library Committee with power to act.

A copy of No. 80 of the Proceedings, just published, was laid on the table by the Secretaries.

Donations for the Library were received from M. Foucou, Mr. O. Warner, Secr'y Com. Massachusetts, Dr. B. A. Gould, Mr. S. Scudder, Boston Public Library, New Jersey Historical Society, Dr. Joseph Parrish, the Blind Asylum, Medical News, Librarian of Congress, Treasury Department, and Dr. Rushenberger.

The death of C. F. P. von Martius, at Münich, December 13, 1868, was announced by letter from his son, Dr. C. A. Martius.

The death of John Cassin, at Philadelphia, January 10, 1869, aged 55, was announced by Dr. Le Conte, and on motion of Dr. Rushenberger, Dr. Bridges was requested to prepare an obituary notice of the deceased.

The following communication was received from Prof. T. C. Porter, dated, Easton, Pa., Jan. 6, 1869.

Mr. Boyd's letter has arrived, and the following extracts contain all the information he can now give concerning the Indian inscriptions near Peach Bottom:

"The rocks from which I copied the figures sent you are granitic, very

hard, and situated in the Susquehanna River about three miles below the Pennsylvania State-line and twelve or fourteen above Havre de Grace. During high freshets they are entirely submerged.

The inscriptions are numerous and in a fine state of preservation when not directly exposed to the abrading force of ice and drift-wood. They occur on the sides and tops of some half dozen rocks. Although at first sight they might seem to have no connection with each other, I have been able to trace an arrangement in horizontal and vertical lines. The grooves are semi-cylindric, and in some cases have a depth of half an inch or more.

My copies were taken by placing sheets of paper on the figures and coloring the portions lying immediately over the grooves. Thus, the outlines, if rude, are faithful and of full size.

Owing to the limited time at my command, I did not copy them all, but confined myself to the more curious.

The people of the neighborhood, although many of them are descended from early settlers who came into contact with the Indians then living there, seem to know nothing as to the origin or meaning of these figures.

I regret that the information I send you is so scanty, but, should the Philosophical Society desire it, it will give me great pleasure to make a thorough exploration of the rocks and their inscriptions, next July, when I expect to spend several weeks not far from the locality."

Dr. Brinton, present on invitation, addressed the Society upon the nature of the Maya group of languages, and, in his opinion, the great value of several manuscript grammars and vocabularies in the Society's Library. On motion of Mr. Fraley, the thanks of the Society were tendered to Dr. Brinton, and he was requested to furnish the Secretaries with an abstract of his remarks.

The Maya group of languages comprises those spoken in the old departments of Yucatan, Vera Paz, Chiapas, Guatemala, and Soconusco. The Huasteca also belongs to it, which was current in the province of Tamaulipas, about Tampico. The Natchez of Louisiana, and the Chahta-Muskoki family display some affinities with it, which have not yet been fully investigated. On the ethnological maps of Pritchard, Waitz, Bastian and Kiepert, and others, the Mayas are located on the Greater Antilles also, and it is the opinion of the Abbé Brasseur de Bourbourg, as well as some other writers, both ancient and modern, that the Mayas and Aztecs both look to the former inhabitants of Haiti—the so called Taini—as their common progenitors. For this opinion there is no sound foundation, as there can be brought abundant evidence to prove that both

the tribes native in Cuba and Haiti, as well as those on the Bahamas, and those resident on the lesser Antilles before the arrival of the Caribs were Arrowacks, and came from South America.

The most important dialects of the Maya are the Yucatecan, the Quiche, the Cakchiquel, the Tzendal, the Pokonchi, the Huastecan and the Zahlopahkap. They are as closely allied one with another as the Romanic tongues of modern Europe, and have many points in common which give them peculiar interest, in fact the very highest interest, among American aboriginal languages.

Not merely were they the dialects of the most cultivated branch of all the red race, from which indeed the civilization of the whole Northern Continent probably proceeded, but they exhibit certain linguistic traits, allying them strangely to the more perfected tongues of the Old World. So strong are these resemblances that of recent writers Brasseur and Bastian both incline to hold them akin to the Aryan family, and possibly largely influenced by Scandinavian immigration in the eleventh century. This however is a baseless hypothesis.

The traits referred to are: 1st. Their less marked polysynthetic structure, approaching at times to a plainly inflectional character; 2d. Their harmonic repetition of vowels like that in Scythian tongues, the suffixes added to change the grammatical character of words often varying their vowel to agree with that in the terminal syllable of the root; 3rd. The pronominal affixes of the verbs, which are added to the verbal root to express the relation of the action, and form a regular conjugation precisely as was the case in the primitive Aryan tongue; 4th. The genesis of the pronouns, which as recently carefully investigated by M. H. de Charency has disclosed laws of growth of very general interest.

In these languages also, is found the only native American literature. The Mayas used a phonetic alphabet as well as ideographic writing, and thus preserved their chronicles and traditions for many centuries anterior to the discovery. At the Conquest, their chief literary monument, called the Book of the Mats (*i. e.* of the nobles, who sat on mats while the common people occupied the floors), the Popol Vuh, was written in Roman Characters in the Quiche dialect. This with several other similar works has been published in the original and with translations in Spanish and French.

As the Maya group may thus be considered the key to the civilization, the mythology, the literature, and earliest possible history of the red race, it is most desirable that any valuable manuscripts which throw light upon it shall be published. Two such exist in the Library of the American Philosophical Society, both short, both of the highest value, both unique and entirely unknown to scholars. One of these is a grammar covering 54 small 4to pages of the Cakchiquel dialect, the other still shorter, embraced on 32 small pages, and is the only existing grammar of the Chol or Putum dialect, spoken by the Lacandones, among the mountains of Vera

Paz. The former dates from 1692, and the author is unknown; the latter is a copy of the grammar of the Dominican missionary Francisco Moran, and is dated 1695. It is in duplicate, by different hands, and as the only known work on the Chol, deserves by all means to be placed within the reach of linguists. A quite full vocabulary is appended, and a sufficient number of prayers and dialogues in the dialect to allow a very satisfactory exhibit to be made of the whole structure of the dialect.

The longer Cakchiquel grammar could likewise be rendered extremely useful by the proper use of other manuscripts in that dialect now in possession of the Society, and which have not hitherto been used. These include several dictionaries, books of sermons, Confessionaries, and a copy of the earliest volume printed in any Central American dialect, the *Doctrina Christiana* of Marroquin, printed at Mexico, 1556.

The enlightened attention which this Society has always given to American linguistics, and the great benefit which the publication of these two small works, enriched by the notes and illustrations for which the Society's Library offers such abundant material, lead me to hope that your honored body will take the necessary steps to render them thus available to the learned world.

Mr. Lesley was nominated and elected Librarian for the ensuing year.

The Standing Committees were chosen for the ensuing year as follows:

Finance—Mr. Fraley, Mr. J. F. James, Mr. Marsh.

Publication—Mr. T. P. James, Dr. Carson, Prof. C. B. Trego, Mr. E. K. Price, Mr. Tilghman.

Hall—Mr. Peale, Mr. P. E. Chase, Mr. S. W. Roberts.

Library—Dr. Bell, Dr. Coates, Mr. Price, Mr. Barnes, Mr. Briggs.

The list of surviving members was read.

On the list, January 1,	1868, U. S. 281,	Foreign,	142—423.
Elected in	1868, U. S. 10,	Foreign,	1— 11.
Deceased in	1868, U. S. 11,	Foreign,	5— 16.
On the list, January 1,	1869, U. S. 280,	Foreign,	138—418.

Nominations Nos. 593—621 were read and spoken to.

The Committee on the Michaux Legacy reported a resolution for empowering M. Carlier of Paris, which was adopted.

New nominations Nos. 622, 623 were read.

The Publication Committee reported a recommendation to

send the second series of the Transactions, complete, to the N. H. S. of Montreal, which was so ordered.

The ballot boxes were then opened by the presiding officer, and the following named gentlemen were declared duly elected members of the Society.

George H. Horne, M. D., of Philadelphia.
William M. Gabb, of Philadelphia.
Hakakian Bey, of Cairo.
Linant Bey, of Cairo.
Auguste Mariette Bey, of Cairo.
Dr. Ceselli, of Rome.
Emmanuel De Rougé, of Paris.
Henri Brugsch.
Johannes Dümichen.
François Chabas, of Chalons sur Sâone.
Samuel Birch, of London.
Edward Lartêt, of Paris.
Joseph Prestwich, of London.
Carl L. Rütimeyer, of Basel.
William H. Flower, of London.
George Rolleston, of Oxford.
Thomas H. Huxley, of London.
Joseph D. Hooker, M. D., of Kew Gardens.
John Phillips, of Oxford.
J. J. A. Worsaae, of Copenhagen.
Sven Nillson, of Lund.
Auguste Carlier, of Paris.
Benjamin S. Lyman, of Philadelphia.
Henry C. Baird, of Philadelphia.
Samuel J. Reeves, of Philadelphia.
Hector Tyndale, of Philadelphia.
Joshua B. Lippincott, of Philadelphia.
Horace Binney, Jr., of Philadelphia.
William Blackmore, of Salisbury (London) England.

And the Society was adjourned.

Stated Meeting, February 5, 1869.

Present, fifteen members.

Dr. GEORGE B. WOOD, President, in the Chair.

Mr. Binney, Gen. Tyndale and Mr. Lyman, new members, took their seats.

Letters of acknowledgment were received from the Academy at Amsterdam, Royal Library at the Hague, Batavian Society at Rotterdam, Zoological and Statistical Societies at London, Leeds Philosophical Society, American Statistical Society, Massachusetts and New Jersey Historical Societies, Boston City Library, Yale College, Peabody Institute, and also from the Philadelphia College of Physicians, returning thanks for a donation of duplicate pamphlets.

Letters of envoi were received from the Geog. Soc., Vienna, June 30; Holl. Soc., Harlem, May 20; Acad., Amsterdam, Sep. 2; Central Bureau of Statistics, Sweden, Nov. 25, 1868.

Donations for the Library were received from Prof. Zantedeschi; the Geographical Societies of St. Petersburg, Vienna and London; Academies and Societies of Amsterdam, Rotterdam, Harlem and Nürnburg; Antiquarian Societies at Copenhagen and London; Central Bureau at Stockholm; Astronomical and Geological Societies at London; Nat. Hist. Soc. and Pub. Lib., Boston; Amer. Oriental Society; Silliman's Journal; Medical News; Acad. Nat. Sci., Philadelphia; Dr. Carson; Wisconsin Historical Society; and Fendall's executors at Washington.

The Librarian communicated for publication in the Proceedings a vertical section of the coal measures of the Georges Creek portion of the Cumberland Basin, made some years ago, with great care, by the State Chemist and Geologist of Maryland, Mr. Philip T. Tyson of Baltimore. On motion it was referred to the Secretaries with power to publish.

SECTION OF CUMBERLAND COAL BASIN.

By Philip T. Tyson of Baltimore.

It contains the position and thickness of rocks of the entire "Potomac Coal Field," amounting to about 1400 feet.

In order to have a fixed base I have made the heights on the left hand margin from the level of tide water, beginning at 670 feet. This was obtained from the maps and profiles of the Baltimore and Ohio Railroad, of which I had copies.

I had also those of the Georges Creek Coal and Iron Company, which connected with the Baltimore and Ohio Railroad. In addition to these I caused numerous other levelings and measurements to be made between Georges Creek and the Savage Mount, and was therefore enabled to construct the entire section from actual measurement, with the aid of very extensive diggings, whilst making Geological Surveys for the Georges Creek Coal and Iron Company in 1852.

This section extends down to the Devonian, and I have also examined and find its beds precisely like those below the Yohogheny Coal Field and the Great Western Field, as seen in the Gap a few miles east of Connellsville.

The measurements from 670 to 1120 feet were taken on the Savage river and Potomac. From thence to 1349 feet on Mill run, which flows into Georges Creek. From thence to 1443 feet on Laurel run, which also flows into Georges Creek. From 1443 feet on the S. E. face of Dug hill, at the foot of which is Lonoconing.

Feet above Tide.	*Thickness.*	*Character of Rock.*
	1′ 6″	Shale.
	2′ 0″	Coal.
2050	19′ 0″	Shaley Sand Stone.
	23′ 6″	Shale.
	6′ 0″	Coal.
	12′ 0″	Limestone with Shale seams.
2000	13′ 9″	Fire Clay.
	3′ 9″	Unknown.
	27′ 3″	Nodules of Iron in Shale.
1950	27′ 9″	Shale.
	3′ 6″	Sand Stone, fine grain.
	2′ 6″	Shale.
	4′ 3″	Coal (2″ shale parting).
	10′ 0″	Fire Clay.
	3′ 6″	Coal.
1900	3′ 0″	Fire Clay.
	51′ 0″	Sand Stone Shaley. Sand Stone Micaceous. Sand Stone Coarse.
1850		
	42′ 6″	Shales, not fully examined.
	4′ 6″	Coal.
	2′ 0″	Shale.

Feet above Tide.	*Thickness.*	*Character of Rock.*
1800	1′ 0″	Coal.
	4′ 9″	Shale.
	10″	Coal.
	1′ 3″	Shale.
	1′ 0″	Shaley Sand Stone.
	4′ 8″	Shale ferruginous.
	14′ 0″	MAIN COAL.
	4″	Bands of Iron ore.
	11′ 8″	Shale.
	3′ 0″	Fire Clay.
1750	1′ 6″	Limestone.
	15′ 6″	Shale.
	29′ 0″	Sand Stone, fine grain.
1700	27′ 6″	Shale.
	2′ 6″	Coal.
	4′ 0″	Shale.
	16′ 8″	Shale. Ore No. 20 at its top.
	1′ 0″	Shale ferruginous.
	3′ 9″	Coal.
	1′ 0″	Shale.
	1′ 0″	Coal.
1650	2′ 6″	Ore Nos. 17, 18 and 19 in Shale.
	3′ 0″	Ore No. 16 in Fire Clay.
	6″	Shale.
	1′ 0″	Coal.
	7″	Ore No. 15 in Shale.
	2′ 0″	Ore balls in stratum of Fire Clay.
	6″	Shale.
	1′ 6″	Coal.
	2′ 6″	Shale.
	5′ 6″	Ores No. 13 and 14 in Fire Clay.
	1′ 6″	Sand Stone.
	6′ 6″	Ores 12, 11, 10, 9 in Shale.
	6′ 6″	Shale with ore balls Nos. 8 and 7.
	7″	Ore No. 6.
	4′ 3″	Shale with ore No. 5.
	6″	Coal.
	6″	Ore No. 4 in Shale.
	1′ 6″	Coal.
	2′ 0″	Shale.
	2′ 3″	Shale and Coal together.
	2′ 2″	Ore No. 3 in Shale.
	2′ 1″	Coal.
	6″	Shale.
1600	2′ 8″	Ore No. 2 in Fire Clay.
	4′ 10″	Ore No. 1 in Shale.

Feet above Tide.	*Thickness.*	*Character of Rock.*
	2′ 6″	Ore in Shale.
	1′ 6″	Upper black band Ore. — Undermine in the 3″ Coal and all the Ore above for 4′ will come down. If stacked in rows and self-washed for a month, it will yield 40 0-0.
	3″	Coal.
	2′ 0″	Shaley Sand Stone.
	4′ 6″	Shale.
	2′ 6″	Coal.
	3′ 0″	Limestone.
	3′ 6″	Fire Clay.
	8″	Coal.
	1′ 6″	Shale.
	1′ 6″	Shale ferruginous.
	1′ 0″	Shale.
	1′ 3″	Coal.
	1′ 3″	Shale.
	1′ 6″	Coal.
	1′ 6″	Shale.
	1′ 6″	Coal.
	2′ 8″	Shale, brown.
	5′ 0″	Shale, sandy with balls.
1550	8′ 0″	Shaley Sand Stone.
	4′ 6″	Shale.
	1′ 6″	Coal.
	7′ 4″	Fire Clay.
	5′ 0″	Shales ferruginous.
	7′ 0″	Shale with balls.
	2′ 0″	Shale ferruginous.
	1′ 0″	Shale.
1500	39′ 0″	Sand Stone.
	15′ 0″	Shale.
	3′ 0″	Ore in Fire Clay.
	6′ 0″	Limestone.
	2′ 0″	Ore in Fire Clay.
1450	10′ 0″	Shale.
	44′ 0″	Sand Stone.
1400	8″	Coal.
	10″	Shale.
	2′ 2″	Limestone
	23′ 6″	Sand Stone.

Feet above Tide.	*Thickness.*	*Character of Rock.*
	6′ 0″	Shale.
	6′ 0″	Hard black band.
	6′ 0″	Shale very ferruginous.
	4′ 6″	Shale.
1350	1′ 8″	Coal Shaley.
	1′ 0″	Coal hard. } 5′ 8″
	3′ 0″	Coal good.
	4′ 0″	Sandy Fire Clay.
	6′ 0″	Ore in Shaley Fire Clay.
	6′ 0″	Limestone.
1300	33′ 0″	Sand Stone.
	9′ 6″	Shale.
	11′ 0″	Ore balls. Marine shells. Balls in Shale.
	2″	Coal.
	6′ 0″	Shale.
	2′ 2″	Coal.
	14′ 0″	Shale.
1250	4′ 0″	Coal.
	25′ 6″	Shales. Fire Clay. Sand Stone. Not explored.
	2′ 0″	Coal.
1200	102′	Unknown. Coal crop near top.
1150		Sand Stone at bottom.
	24′ 0″	Ferruginous Shale. Grey Shale.
1100		Black Shale.
	2′ 0″	
	6″	Six feet Coal.
	3′ 6″	
	3′ 0″	Fire Clay.
	6′ 0″	Shales with balls of ore.
	27′ 0″	Unknown.
	8′ 0″	Coal.
1050	4″	Shale.
	19′ 0″	Sand Stone.
	8″	Coal.
	20′ 0″	Shales. Fire Clay. Shales. Fire Clay.
	1′ 6″	Coal.

Feet above Tide.	*Thickness.*	*Character of Rock.*
1000	10′ 0″	Fire Clay.
950	92′ 0″	Sand Stone [XII].
		This rock is constant. It makes the flat summit of the west mountain; and, north of Savage creek, has lying on it isolated cubic blocks, fragments of itself, as large as three story houses, very remarkable objects.
	3′ 0″	Large balls of ore.
900	14′ 6″	Shale.
	3″	Shale Coal.
	12′ 3″	Sand Stone, thin layers.
	2′ 0″	Coal.
	2′ 6″	Shale.
850	42′ 6″	(Sand Stone, &c., not explored.)
	7′ 6″	Ore in Shale.
800	83′ 0″	(Principally Sand Stone, ?)
750	2′ 6″	Coal.
	? ?	Shale. Small interval.
	27′ 0″	Sand Stone, thin bedded.
	2′ 0″	Lowest known coal bed.
	160′ 0″	Principally Sand Stone, but not much
550		explored.
	90′ 0″	Green Shale of XI.
450	? ?	Grey Limestone of XI.

Mr. Chase communicated the results of a careful discussion of Philadelphia Life Tables, extending through 62 years, and including more than 400,000 lives.

On motion of the Librarian, the subject of the propriety of publishing the MSS. grammars of the Chol and Cokchiquel languages, in the Society's Library, was referred to the Publication Committee, to report thereon, after consultation with Dr. Brinton.

Pending nominations Nos. 622, 623 were read.

At Prof. Coffin's request and on motion of Prof. Kendall, the Officers of the Society were authorized to sign a memorial to Congress praying for a sufficient appropriation for observing properly the total eclipse in August next.

On motion of Mr. Fraley the renting or otherwise disposing of the Hall was referred to a committee consisting of Messrs. Price, Fraley, Welsh, Rushenberger and Cresson.

And the Society was adjourned.

Stated Meeting, February 19, 1869.

Present, fourteen members.

Mr. FRALEY, Vice-President, in the Chair.

Dr. Horn, a newly elected member, took his seat.

Letters accepting membership were received from Samuel Birch, dated British Museum, London, February 2d, and William H. Flower, dated College of Surgeons of England, London, February 1, 1869.

Letters of acknowledgment were received from the London Antiquarian Society, Nov. 23, 1868, for No. 77, the Essex Institute, Rhode Island Historical Society and University of New York City, all for No. 80 of the Proceedings.

A letter from M. Chevalier announced the transmission of a set of the reports of the Jury of the International Exposition of 1867.

A letter from Prof. Coppeé enclosed a receipt for Mariana's History of Spain.

Donations for the Library were announced from Prof. Zantedeschi, the Russian Academy, French Geographical Society, B. N. H. Society and Public Library, Mr. Eli K. Price, Dr. Kirkbride, Prof. Cope and Hon. Charles Sumner.

The death of Charles N. Bancker, at Philadelphia, February 16, 1869, aged 91, was announced by Dr. Hays with appropriate remarks, and on motion of Mr. Fraley, Judge Cadwallader was requested to prepare an obituary notice of the deceased.

Mr. Lea communicated for publication in the Transactions "Remarks on Thirteen New Species of Crinoidea, from the

Palæozoic rocks of Indiana, Kentucky and Ohio, &c. By Sidney S. Lyon of Louisville, with 4 plates," which was referred to a committee consisting of Mr. Lea, Mr. Cope and Mr. Lesley.

The Secretary, in the absence of Dr. Leidy, communicated for publication a memoir "On the Geological Age and Equivalents of the Marshall Group. By Prof. A. Winchell." Which was referred to a committee consisting of Mr. Lesley, Dr. Le Conte and Dr. Leidy.

A letter from Prof. F. V. Hayden communicated "Notes on the Geology of Wyoming and Colorado Territories, No. 2, with 6 wood cuts, already cut, and two ink sketches," which was referred to the Secretaries with power to act.

Prof. Cope exhibited and described a jaw of *Mylodon annectens* from the post-tertiary rocks of South America.

Prof. Cope exhibited the mandible of a gigantic sloth from the post-tertiary of the Banda Oriental in South America. He stated that it belonged to the genus Lestodon (Gervais) but approached in its characters the Myodon of Owen. He pointed out the anterior canine teeth of Megalonyx, the posterior canines of Lestodon, and the reduction of the same in Mylodon to the character of small premolars, less than the molars. In the species exhibited, the canine is removed to close proximity to the molars, and was as large as the first, immediately following it. The species differs not only in this respect, but in the form of this and other teeth from the Mylodon robustus (Owen), to which it is nearly related. The form of the symphysis is not very different, but is turned outwards at the anterior angles and emarginate medially. The lateral margin concave. The canine directed upwards, and more outwards than the molars. Its section presents longer straight inner and anterior sides, and a short convex outer side, which is connected to the inner by an oblique, slightly concave side. The second tooth or molar about the same size, and of subtrifoliate section, the outer lobe more obtuse, and less strongly separated by alveolar ridges than the two inner from each other. Third molar quite oblique, directed backward and inward, the section composed of four arcs separated by alveolar ridges. Posterior part of alveolus of last molar broken away, the anterior part narrower and more oblique than any other tooth.

Prof. Cope stated that the species seemed to be near the Lestodon myloides of Gervais, which was however so briefly described as to be scarcely recognizable. According to the characters of Lestodon, the canine tooth appears to be at a greater distance from the molar than in

the present animal, where that distance is only twice as great as that between the first and second molars.

Prof. Cope described several points of novelty and importance in the memoir on the Fossil Batrachia of North America, which the Society is publishing in Part 1 of Vol. XIV. of its Transactions; and expressed a desire that the Society should permit him to illustrate the memoir with additional plates.

He pointed out that all the tortoises of the Cretaceous yet discovered were fresh water forms, many allied to Chelydra, and that there were no extinct land tortoises or Testudinidae in North America, the species from the Western Territories referred hitherto to Testudo being in fact Emydidæ. He called attention to the peculiar characters of the Mosasaurs and of the Streptosauria, as not having been previously pointed out, and stated there were eleven species of the first named group known to him from North America. One of these, M. depressus Cope, common in New Jersey, is defined by the transverse ovate form of the vertebral centra throughout the column, and the presence of a prominent rib of the outer face of the quadrate bone, throwing the meatal pit inward, and not reaching the proximal articular face.

He mentioned also the modifications of form in the Dinosaurian skeleton, by which an approach to the Birds was indicated. Thus the ilium from a vertical, assumed a transverse position, the acetabulum being thrown upward and forward, while the great size and inferior and posterior position of the other pelvic elements transformed the weight of the viscera posteriorly, to beneath the support. The consequence of this was the inclosure of a longer series of vertebræ as sacral, derived from the lumbar series, and the support of the body by a powerful hind limb, more nearly beneath the centre of gravity than in other types of reptiles.

An additional approximation to the birds was seen in the hind limbs. The head of the femur was transverse to the condyles, and the crest of the ilium furnished with a very elevated crest. In the more quadrupedal forms as Iguanodon and Hadrosaurus the crest was much curved outwards, while in the biped types as Laelaps and Pœcilopleurum the crest projected more forward. In the latter also the astragalus embraced the tibia in the closest manner, and presented to the foot at a remarkable angle. In Compsognathus this element had united with the tibia as in birds. The latter and Stenopelix Myo, he stated to be the best preserved in pelvic characters. He stated that these affinities had been explained by him at a meeting of the Academy of Natural Sciences of Philadelphia, in Feb., 1867, and had since been confirmed by other authors.

Nominations Nos. 622 and 623, and new nominations Nos. 624, 625, 626 were read.

And the Society was adjourned.

PHILADELPHIA LIFE TABLES.

By Pliny Earle Chase.

More than forty years ago Dr. Gouverneur Emerson, in the American Journal of the Medical Sciences, began his discussion of the vital statistics of Philadelphia.* His connection with the Board of Health gave him ready access to the original returns, and after subjecting them to a rigid scrutiny, he became satisfied that the sanitary condition of the city was remarkably good.

Doctors W. S. W. Ruschenberger, Wilson Jewell, James N. Corse and W. Lehman Wells, on behalf of the Committee on Epidemics and Meteorology, of the Philadelphia College of Physicians, subsequently published some interesting local nozological tables and conclusions. I cannot find that any other noteworthy use has been made of a valuable mortuary record, which has been kept with great care, and without interruption, from the commencement of the year 1807 until the present time.†

At the request of the Provident Life and Trust Company of Philadelphia, I have recently computed two comparative life tables, from the

* Among the results developed by Dr. Emerson's investigations connected with the movement of population and vital statistics of Philadelphia, embracing a period of about thirty years from the year 1807, when the first official Bill of Mortality was issued, are the following:

1. Great healthfulness of the city proper, in which the annual proportion of deaths to the population was only 1 in 56 (See Am. Med. Journal for Nov. 1827).

2. Excessive mortality in the colored population (Ibid).

3. Improved condition of colored population as indicated by reduction of mortality.

4. Excessive mortality of children in the warm months, and demonstration of the fact that the deleterious operations of heat are almost entirely confined to the first months of life, the influence of the seasons upon infantile mortality being scarcely perceptible after the first year of life has passed.

5. The excessive mortality of male over that of female children in the first stages of infancy, and demonstration that this is not owing, as commonly supposed—to greater exposure of male children to accidents, but to diseases and physiological causes peculiar to each sex (Am. Jour. of Med. Sciences, 1827 to 1831).

7. Practical conclusions drawn from results last mentioned (Ibid).

8. Seasons when most births take place (Ibid. Nov., 1845).

9. Influence exerted through epidemic cholera and other depressing agencies, tending to reduce the preponderance of male births (Same Journal for July, 1848, p. 78).

† "From authority vested in the Board of Health, this municipal power makes it obligatory upon physicians to give certificates designating the name, age, and sex of all who die under their care, and sextons are bound by still heavier penalties not to permit the interment of any dead body until such certificate is obtained, which he returns to the Health Office on the last day of every week, for publication" (Emerson; op. cit., vol. I, p. 117).

returns of the Board of Health, and of the several monthly meetings of the Society of Friends in the city and its immediate neighborhood.

The general Philadelphia table is more extensive than any table hitherto published for a single locality, being based upon records of 425,502 interments, 265,590 births, and seven successive decennial census enumerations.

The Friends' table is based upon records of 14,666 interments, 4,264 births, and eight enumerations of membership. This is the first table ever published that affords any basis for estimating the sanitary advantages of moderation, temperance, and a general regard for the laws of health and morality. The tables which have been constructed from the experience of different Tontines and Life Insurance Companies exhibit some of these advantages, with the added indeterminate advantage of medical selection.

The following definitions and explanations may facilitate the study of the tables :

The *possible life*, is the limit which is sometimes attained in a given district.

The *probable life* ("*vie probable*"), is the term at which one half of those who are born alive will have died. It is the age, the probability of living beyond which is as great as that of dying before the age is attained.

The *probable life at any age*, is the term at which one half of those who are living at that age will have died.

The *expectation of life* ("*vie moyenne*"), is the average age which will be attained by all who are born.

The *expectation of life at any age*, is the average after life-time of *all* who are living *at that age*.

The *mean expectation* is the average after life-time of *all* who are living.

The *proportionate mortality* at any age, is the ratio of the number dying during the year following that age to the number living at the precise age.

The *vitality* at any age, is in inverse ratio to the proportionate mortality at that age. If, for example, out of 1000 children born alive the average number of deaths under 1 year of age is 180.38, the proportionate mortality per 1000 is 180.38, and the vitality is $\frac{1000.00}{180\ 38}$ or 5.54.

Neither the *mean age at death* nor the *mean age of the living* furnishes a sufficient clue to the expectation of life, or any independent criterion of salubrity. Emigration, immigration, excess of births over deaths or of deaths over births, zymotic diseases, and other circumstances, variously disturb the normal values which are embraced in a perfect life table. Such a table represents an ideal stationary population, or one in which the number of annual births is exactly equal to the number of annual deaths, and one which is not affected by emigration or immigration.

By a joint examination, in accordance with the formulas of De Morgan, Davies and Farr, of the numbers living at any given age and the numbers dying at the same age, the disturbances to which all populations are subject can be mostly eliminated, and results obtained which will afford a proper basis for comparisons.

There are, however, some elements of uncertainty which cannot be removed by any method hitherto proposed. Among these are the following:

1. The old and still mooted doctrine of climacterics, or critical periods of life in which some great constitutional change is supposed to take place, appears to derive some confirmation from such irregularities as the alternate diminution and increase of proportionate mortality, in the Carlisle table, at the ages 21, 22, 31, 33, 46, 50, 89, 90, as well as from the increase of expectation, in the Carlisle table from 91 to 95, in Quetelet's Belgian table from 89 to 91, and in the Philadelphia table from 91 to 100.

2. Wherever a population is affected by immigration, two classes of disturbance may be looked for; one arising from the poorer class of immigrants, who live in the most unhealthy neighborhoods, exposed to privations and hazards which increase the mortality of infancy and youth; the other from a better class, like our house servants, the agents of importing houses, and persons of some property, who increase the average vitality towards the close of life.

3. In many places, especially in cities, almshouses and asylums for the aged furnish comforts which tend to prolong life. The tendency is aided by the freedom from care and anxiety, the infrequency of exhausting mental effort, and the watchfulness of friends or nurses.

4. In a Society with birthright membership, like the Society of Friends, nearly all the deaths in infancy and youth may be entered on the records. But after reaching maturity the ties of membership are often sundered for various reasons, and many of the deaths in old age may escape notice. The ratios of apparent mortality will thus be affected unfavorably, during the whole course of life.

According to the census of 1860, the foreign-born residents of Philadelphia constituted nearly thirty per cent. of the entire population. On this account any comparisons with other life-tables either in infancy or old age might convey an erroneous impression. But the mean expectation is probably but little affected by the foreign element, and it may very properly be considered in the following comparison with two of the most celebrated and one of the most unfavorable foreign tables.

Comparative mean expectations:

Price's London	23.70	years.
Philadelphia	31.46	"
Farr's English, No. 3, male	31.77	"
" " " female	32.33	"
Carlisle	32.66	"
Friends'	33.11	"

Notwithstanding the increased juvenile mortality consequent upon immigration, the Philadelphia table shows a possible life of 114, a probable life of 33.44, and an expectation of 35.09. I know no other city of much magnitude in which so favorable vital conditions have ever been reported.

In preparing the Philadelphia table the following values were ascertained:

Ratio of deaths of colored persons to entire number of deaths; for 62 years	8.7 per cent.
Do. from 1863 to 1867, inclusive	6.7 "
Average mortality, 62 years	1 in 47.836.
" Colored mortality, 62 years	1 in 27.766.
" " " 1858 to 1862, inclusive	1 in 34.780.
Ratio of still-births to total births	4.3 per cent.
" " " " deaths	5.8 "
" " living births to population	2.8 "
" " deaths to births	74.5 "
Natural annual increase	$\frac{5}{7}$ "
Average " "	3.3 "
" " immigration	2.6 "
Mean age at death	23.57 years.
" " of the living	24.29 "

Dr. Emerson's discussions showed a ratio of deaths of colored persons, as great as 16 per cent. of the entire number of deaths; an average white mortality varying between 1 in 38.25 and 1 in 56.53; an average colored mortality of 1 in 19 from 1807 to 1820 inclusive, and of 1 in 27.2 from 1821 to 1830 inclusive. We have no means of determining the ratio of colored mortality since the close of the war, but even if it should show a temporary increase, there can be little doubt that the general sanitary improvement noted by Dr. Emerson still continues. The diminution in the per centage of colored deaths, from 16 per cent. to 6.7 per cent., is attributable in part to this general improvement, and in part to the preponderating increase of the white population.

The advantages of regular habits are shown by the following comparisons:

	Friends.	*Philadelphia.*	*Advantage.*
Maximum vitality (age 12)	310.56	257.74	20.49 per cent.
Average proportionate mortality from 20 to 60 years of age	14.25	17.58	23.37 "
Expectation of life	43.73	35.09	24.62 "
Probable life	48.08	33.44	43.78 "
Proportionate mortality at birth	124.66	180.38	44.70 "

PHILADELPHIA GENERAL LIFE TABLE.

Age.	Living, Number.	Dying, Number	Proportionate Mortality, per 1000.	Expectation, Number of years.	Age.	Living, Number.	Dying, Number	Proportionate Mortality, per 1000.	Expectation, Number of years.
0	100,000	18,038	180.38	35.09	58	30,799	891	28 93	15 97
1	81,962	7,540	92.00	41.71	59	29,908	905	30 25	15 43
2	74.422	4,427	59.48	44 88	60	29,003	918	31.65	14.89
3	69,995	2,982	42 60	46.59	61	28,085	931	33.18	14.36
4	67,013	2,039	30.43	47.74	62	27,154	946	34.84	13.84
5	64,974	1,387	21.35	48.23	63	26,208	961	36.66	13 32
6	63,587	943	14 83	48 27	64	25,247	978	38.72	12 81
7	62,644	651	10 40	47.99	65	24,269	996	41 04	12.30
8	61,993	470	7.58	47.49	66	23,273	1,016	43.64	11.81
9	61,523	362	5.88	46.84	67	22.257	1,036	46.55	11.32
10	61,161	297	4.88	46.12	68	21.221	1,055	49 75	10 85
11	60,864	251	4.14	45.34	69	20,166	1,073	53.22	10 39
12	60,613	236	3.88	44.53	70	19,093	1,087	56.94	9.95
13	60,377	238	3.95	43 70	71	18,006	1,096	60 88	9.52
14	60,139	255	4 24	42 87	72	16,910	1,101	65 08	9.11
15	59,884	278	4.64	42.05	73	15,809	1,098	69.48	8 71
16	59,606	307	5.18	41 24	74	14,711	1,090	74.10	8 32
17	59.299	343	5.76	40 45	75	13,621	1,076	78.96	7.94
18	58,956	378	6.40	39.69	76	12.545	1,054	84.06	7 58
19	58,578	414	7.10	38 94	77	11.491	1,028	89.44	7.23
20	58,164	456	7.83	38.21	78	10.463	995	95.14	6.89
21	57,708	493	8.55	37.51	79	9.468	959	101.20	6.57
22	57,215	529	9 24	36 83	80	8,509	916	107.66	6 25
23	56,686	560	9.88	36.17	81	7,593	870	114.56	5 94
24	56,126	587	10 48	35 52	82	6,723	819	121.92	5 65
25	55,539	610	11.00	34.89	83	5,904	767	129.80	5.36
26	54,929	629	11.45	34.28	84	5,137	710	138 18	5.09
27	54,300	643	11 83	33.67	85	4,427	651	147.08	4 82
28	53,657	653	12 18	33 07	86	3,776	591	156.57	4 57
29	53,004	662	12 50	32.47	87	3,185	539	169 20	4.32
30	52,342	672	12 84	31.87	88	2,646	484	183.42	4.10
31	51,670	681	13 18	31.28	89	2,162	439	203 10	3 91
32	50,989	689	13 52	30.69	90	1,723	389	225.54	3.78
33	50,300	698	13 88	30 10	91	1,334	319	239.32	3 63
34	49,602	706	14 24	29.52	92	1,015	247	243 00	3.75
35	48,896	716	14.63	28.94	93	768	187	244.22	3 79
36	48,180	722	15.00	28 36	94	581	142	244.22	3 85
37	47,458	730	15.38	27.79	95	439	107	243.36	3.91
38	46,728	736	15 76	27 22	96	332	80	239.67	4.04
39	45,992	743	16.15	26 64	97	252	59	234.40	4.16
40	45,249	748	16.53	26.07	98	193	43	225.54	4.28
41	44,501	754	16 94	25 50	99	150	31	205.67	4 38
42	43,747	760	17.38	24 93	100	119	23	192.76	4.39
43	42,987	766	17.83	24 36	101	96	18	186.42	4.31
44	42,221	772	18 30	23.79	102	78	14	182 86	4.19
45	41,449	778	18.78	23.23	103	64	12	180.78	4.01
46	40,671	784	19.28	22.66	104	52	9	179.65	3 79
47	39,887	789	19.78	22 10	105	43	8	178.90	3 51
48	39.098	795	20 33	21 54	106	35	6	178 60	3 16
49	38,303	800	20.90	20 97	107	29	5	181 54	2 75
50	37,503	807	21.50	20.41	108	24	6	189.04	2 25
51	36,696	813	22.15	19.85	109	18	6	205 12	1 74
52	35,883	821	22 88	19.28	110	12	5	. .	1.37
53	35,062	830	23 66	18 72	111	7	4	. .	1.05
54	34,232	840	24 54	18 17	112	3	2	. .	.80
55	33,392	851	25 50	17.61	113	1	1	. .	.50
56	32,541	865	26 56	17.06	114				
57	31,676	877	27.70	16.51					

PHILADELPHIA FRIENDS' LIFE TABLE.

Age.	Living, Number.	Dying, Number	Proportionate Mortality, per 1000.	Expectation. Number of years.	Age.	Living, Number.	Dying, Number	Proportionate Mortality, per 1000.	Expectation. Number of years.
0	10,000	1247	124.66	43 73	58	4,204	96	22.90	16.87
1	8,753	511	58 38	48.89	59	4,108	101	24.45	16.25
2	8,242	272	33.06	50 89	60	4,007	104	26.12	15.64
3	7,970	192	24 08	51.61	61	3,903	109	27.95	15.05
4	7,778	137	17.62	51 87	62	3,794	114	29 90	14 47
5	7,641	99	12.95	51.79	63	3,680	118	32 00	13 90
6	7,542	72	9 55	51.46	64	3,562	122	34 26	13 34
7	7,470	53	7.12	50 95	65	3,440	126	36.72	12 80
8	7,417	40	5 40	50 32	66	3,314	130	39.40	12.27
9	7,377	31	4 25	49.59	67	3,184	135	42 32	11.75
10	7,346	27	3.56	48.80	68	3,049	139	45.50	11 25
11	7,319	23	3.24	47.97	69	2,910	142	48.94	10.76
12	7,296	24	3 22	47 12	70	2,768	146	52.68	10.29
13	7,272	25	3.42	46.27	71	2,622	149	56.70	9.83
14	7,247	27	3 80	45.43	72	2,473	151	61.04	9.39
15	7,220	31	4.28	44.60	73	2,322	152	65.65	8.97
16	7,189	35	4 85	43.79	74	2,170	153	70.58	8.56
17	7,154	39	5 48	43.00	75	2,017	153	75.82	8.18
18	7,115	44	6.18	42.24	76	1,864	152	81 32	7.81
19	7,071	49	6.90	41.50	77	1,712	149	87 10	7 45
20	7,022	54	7.66	40.78	78	1,563	145	93.14	7 12
21	6,968	58	8 33	40 09	79	1,418	141	99 42	6.80
22	6,910	62	9.00	39.43	80	1,277	136	105.96	6 49
23	6,848	66	9 55	38 78	81	1,141	128	112 72	6 20
24	6,782	68	10.00	38.15	82	1,013	122	119 72	5 93
25	6,714	69	10.40	37.53	83	891	113	126.94	5.67
26	6,645	72	10.72	36.92	84	778	104	134.40	5 42
27	6,573	72	11 00	36 31	85	674	96	142.10	5 18
28	6,501	73	11.24	35 71	86	578	87	150 00	4.95
29	6,428	74	11 48	35 11	87	491	77	158.10	4 74
30	6,354	74	11.70	34.51	88	414	69	166 42	4 54
31	6,280	75	11 90	33.92	89	345	61	174 93	4 34
32	6,205	75	12 10	33.32	90	284	52	183.66	4 16
33	6,130	75	12 31	32.72	91	232	44	192 62	3.98
34	6,055	76	12.48	32.12	92	188	38	201 80	3 81
35	5,979	76	12.65	31.52	93	150	32	211 25	3.65
36	5,903	75	12 84	30 92	94	118	26	220.98	3.49
37	5,828	76	13 02	30.32	95	92	21	231.02	3.34
38	5,752	76	13 18	29 71	96	71	17	241.38	3.20
39	5,676	76	13 32	29 10	97	54	14	252 14	3.05
40	5,600	75	13.45	28.49	98	40	10	263.30	2.91
41	5,525	75	13.58	27.87	99	30	9	274.92	2.78
42	5,450	75	13.72	27 25	100	21	6	287.02	2.64
43	5,375	74	13.85	26 62	101	15	4	299.66	2 50
44	5,301	74	14.00	25.99	102	11	4	312.92	2.35
45	5,227	74	14.13	25 36	103	7	2	326.85	2.19
46	5,153	74	14 28	24.71	104	5	2	341 54	2.01
47	5,079	73	14.46	24 06	105	3	1	356.75	1 80
48	5,006	74	14.68	23 40	106	2	1	372.87	1 52
49	4,932	73	14 95	22 74	107	1	0	389 96	1.12
50	4,859	75	15.30	22.08	108	1	1	. .	50
51	4,784	75	15 78	21.41	109				
52	4,709	77	16 40	20 75	110				
53	4,632	79	17 15	20.09	111				
54	4,553	83	18 02	19 43	112				
55	4,470	85	19.04	18.78	113				
56	4,385	89	20.20	18.13	114				
57	4,296	92	21 48	17.49					

Stated Meeting, March 5, 1869.

Present, eighteen members.

Dr. WOOD, President, in the Chair.

Mr. Baird, lately elected a member, was introduced to the presiding officer and took his seat.

Letters accepting membership were received from J. J. A. Worsaae, dated Castle of Rosenborg, Copenhagen, February 4, 1869; from J. Chabas, dated Chalon sur Saône, Feb., 1869; from Ed. Lartêt, dated Paris, No. 25 Rue Lacépède, February 15, 1869; from T. H. Huxley, dated Royal School of Mines, Jermyn Street, London, February 16, 1869; and from W. M. Gabb, dated Philadelphia, February 19, 1869.

A letter declining appointment to prepare an obituary notice of John Cassin was received from Dr. Bridges, dated Philadelphia, February 20, 1869.

Letters acknowledging the receipt of the published Proceedings of the Society, Nos. 75, 76, 77, were received from G. Kirchhoff, dated Heidelberg, October 22, 1868; from Professor Hornstein, Director of the Prague Observatory, dated November 5, 1868; and from the Royal Society of Antiquaries, Copenhagen, September 1, 1868.

Letters of invoice were received from the Royal Society of Antiquaries; the Jablonowsky Society of Leipsic, November 11, 1868; the Academy of Sciences at Vienna, November 4, 1868; the Swiss Polytechnic School at Zurich, November 27, 1868; the Royal University at Norway, Christiania, November, 1868; and the United States Legation at Paris, February 8, 1869.

A letter was read from M. A. Carlier to Mr. Durand, respecting proceedings taken in the case of the Michaux Legacy.

Donations for the Library were received from the Natural History Society at Moscow, the Geographical Society and Physical Observatory at St. Petersburg, the Royal University of Norway, the Royal Saxon Society, the Prince Jablonowsky Society at Leipsic, the Societies at Görlitz, Emden, Lausanne, and Geneva, the Academy of Sciences at Vienna, the Geographical Society and Bureau des Ponts et Chaussées at Paris, the Royal Astronomical, Meteorological and Chemical Societies of London, Sir John F. W. Herschel, the Boston Natural History Society, the New York Lyceum, the Franklin Institute, the Medical News, the Episcopal Church Hospital, Gen. W. F. Palmer, the Rev. Albert Barnes of Philadelphia, the Peabody Institute of Baltimore, the Public Library of Cincinnati, the University of Michigan, and the California Academy of Sciences at San Francisco.

A record was made of the decease of J. K. Paulding and Alexander Stevens, M. D., of New York.

The committee to which was referred the paper on thirteen new species of Crinoidea, in the Palæozoic rocks of North America, in Kentucky, Indiana and Ohio, by Col. S. S. Lyon of Louisville, presented their report, recommending its publication in the Transactions of the Society, which, on motion, was so ordered.

The committee to which was referred the paper on the Marshall Group, by Prof. A. Winchell, reported, recommending its publication in the Proceedings; on motion, it was referred to the Secretaries with power to act.

Pending nominations Nos. 622 to 626 were read.

And the Society was adjourned.

NOTES ON THE GEOLOGY OF WYOMING AND COLORADO TERRITORIES.

No. 2.

By F. V. Hayden.

Before describing the geological character of the Laramie Plains and the country to the west of it, I will attempt to present a resumé of the physical geography of that very interesting region. If we look at the profile of the route constructed by the Union Pacific Railroad for their road from Omaha to Fort Bridger, we shall find that at Omaha, the initial point, the altitude is 968 feet above tide level. At the mouth of Lodge Pole creek, a distance of 377 miles, we have an elevation of 3528 or a gradual rise in that distance of 2560′ or a grade of about 7 feet to the mile. From the mouth of Pole creek to Crow creek crossing near Cheyenne 513.76 miles west of Omaha we have reached an elevation of 6019 feet, or an average grade of over 9 feet to the mile for the entire distance.

At Evans' Pass on the summit of the Laramie range, we have reached the highest point in the Rocky Mountains, 8248′, a distance of 545.62 miles west of Omaha. The average grade is over 13 feet to the mile. But for 100 miles west of Omaha the average grade of ascent increases as we approach the mountains.

If we take the distance from Crow Creek Crossing at the foot of the mountains to Evans' Pass, "the Summit," a distance of 31.86 miles, we have an average grade of ascent of nearly 70 feet to the mile. We can see clearly by these figures the plan of growth of that portion of our continent west of the Mississippi. A number of these profiles have been constructed across the continent from the Mississippi to the Pacific ocean, from the north line to the south, all pointing to the same result, and all agreeing substantially in the aggregate results.

Passing over this first range of mountains to the Laramie plains, from Crow Creek Crossing to Laramie river 57.53 miles, and 571.39 miles west of Omaha, the elevation is 7175 feet above tide water. Showing that even in the plain country on the west side of the first range the elevation is over 1000 feet higher than at the base of the mountains on the east side.

From the latter point westward there is a continued line of ascent and descent produced by the same forces that elevated the whole Rocky Mountain Chain. Passing the Humbolt mountains we then descend by a moderate grade to the Pacific ocean. The intermediate portions are occupied by a continued series of more or less elevated mountain ranges with intervening valleys which are always at a considerable height above the sea, but vary at different points from east to west. For example the elevation of the Laramie plains near Fort Sanders is 7175 feet, at Salt Lake Valley 4285, making a difference of 2990 feet. We shall endeavor to show hereafter that this difference in the elevation of the two localities of nearly 3000 feet operates most favorably upon the agricultural resources of Salt Lake Valley. While the summers in the Laramie plains are very brief, and it will always be difficult under the most favor-

able circumstances to produce crops to any extent, the productions of Salt Lake Valley are among the finest in the world.

We can see at a glance therefore that the whole country west of the Mississippi is as it were an elevated Plateau, out of which rise, as if by the bursting of the crust, a vast series of ranges of mountains, trending in the aggregate nearly north-west and south-east, and each of the series made up of an infinite number of minor ranges trending in almost every possible direction. In many instances important ranges of mountains are separated from the main chain by extended plains composed of cretaceous or tertiary formations, and without a knowledge of the geological structure of the country, they would seem to be entirely disconnected.

The Black Hills of Dakota, occupy an area of 6000 square miles. If we examine the map this important range seems to be entirely isolated from the main range, but from the south-western side extends a low anticlinal valley, just exposing the tertiary and for a portion of the distance the cretaceous beds, and linking the Black Hills with the Laramie range near Fort Laramie.

Again, the same may be said of the Big Horn range, from the south-east end of which along the valley of Poison Spring creek extends an anticlinal valley, joining the Big Horne range with the Laramie near the Red Buttes. All these isolated ranges, however distant they may appear to be from the main range, or however small they may be, are really connected to the eye of the geologist. It is thus that the anatomy of this great mountain system can be worked out in detail. Never can it be well done, so as to command the unqualified approbation of the scientific world, until the minutest topography and the geology are united together.

The northern portion of the Laramie range properly commences near the Red Buttes. Here the nucleus of feldspathic granite or syenite is concealed by the overlying unchanged beds, and a broad interval occurs which is occupied by a great variety of formations, ranging from the carboniferous to the most recent tertiary. In its southward extension this range seems to flex around from an almost easterly trend to a south-west direction, forming almost a half circle. It then joins on to the main range in the neighborhood of Long's Peak. Thus the Laramie range constitutes the east side and the greater part of the north side of the Laramie plains which forms, thus enclosed, a huge park. On the south side is the Medicine Bow range, the loftiest ridges covered with perpetual snow. Connected with this range also are numerous minor ranges. The west side is an open rugged barren sage plain, with here and there detached small mountains extending far westward toward Salt Lake valley.

The Laramie range forms the most beautiful illustration of an anticlinal ridge I have ever met with in the Rocky Mountains, with the exception of the Black Hills of Dakota. Either one of these ranges if thoroughly studied, would form excellent monographs of the physical geography and geology of the mountain region.

The nucleus of the Black Hills is composed of red feldspathic granite

and other metamorphic rocks, and inclining from the flanks may be seen the upturned edges of the Potsdam sandstone, Carboniferous limestones, brick red sands and sandstones. Triassic, Jurassic marls, Cretaceous and Tertiary rocks, all dipping at various angles, but in such a way as to be easily accessible to the student.

The Laramie range is equally systematic in its plan of development but rather more complicated, and the results of erosive action are much more strongly shown and the superficial deposits or drift in many places conceal the underlying rocks. Like the Black Hills the Lamarie range does not give rise to any important streams of water. Myriads of little streams originate in or near the dividing ridge and cut their channels down the slopes and flow into the North or South forks of the Platte.

The main branch of the North Platte rises in the range of mountain which forms the north side of the Middle Park, very near Long's Peak. It takes a course a little west of north, flows through the middle of the north park, cutting its way through immense canons between the North Park and the Laramie plains. It then continues nearly a north course through tertiary as well as cretaceous rocks to its junction with the Sweet Water, when it bends around to the eastward so that near the Red Buttes its course is nearly south-east until it reaches the main Platte near Long. 101°.

The Sweet Water, which is the principal branch of the North Platte, rises in the southern end of the Wind river mountains, and flows nearly east and unites with the North Platte near Independence. These streams flow through nearly every variety of geological formations which occur in the West. From the junction of the Sweet Water to Red Buttes, it flows through granite, carboniferous limestone, red beds, jurassic marls, and White river tertiary beds. From the Red Buttes, through lignite-tertiary to a point about 100 miles north-west of Fort Laramie. There the White river tertiary beds overlap the lignite-tertiary, and then contiuue to the forks of the Platte.

The Medicine Bow and the two Laramies are important branches of the North Platte, and take their rise in the lofty snow capped mountains on the south side of the Laramie plains. The region north of the North Platte is mostly a vast sage plain and but few small branches flow in from that direction, but a multitude of small streams cut deep channels through the sides of the Laramie range and flow into the North Platte.

From Red Buttes to Fort Lamarie, a distance of 150 miles, many beautiful little streams rise in the Laramie and pour a good volume of water into the Platte. These creeks occur every few miles, and in their passage from the mountain they have not only worn a deep channel in the steep side of the mountain, sometimes 1000 feet or more in depth, but they have also scooped out a wide deep valley which affords the best of pasture, ground for stock in summer and warm sheltered places in winter.

The main branch of the South Platte rises in the range of moun-

tains which bounds the west side of the south park, and flows about north-east to Cache la Poudre, and there bends round slightly toward the east and joins the main Platte. The little branches that flow from the mountain sides are very numerous, and each one cuts a tremendous channel through the sides of the mountain, affording most excellent sections of the strata for the geologist. Nearly all the branches that rise in the plains have very wide valleys, but are mostly dry, especially in the latter part of the summer and autumn. Although the Platte river is never navigable at any season of the year, yet the area drained by it is immense, at least 800 miles from east to west and 350 from north to south, or an area of nearly 300,000 square miles; and yet the North Platte is one of the minor branches of the Missouri river.

The South Platte flows through the different formations along the flanks of the mountain; and in its course through the plains cuts the lignite-tertiary for 50 miles or more, when the White river tertiary overlaps the plains to the junction.

The above brief remarks are intended principally to show by the geography the gigantic scale upon which every thing in this Western Country is planned, that even the district drained by the Platte and its branches is larger than all New England, New York and Pennsylvania.

September 1st, I left Fort Sanders with my party to examine the country along the southern border of the Laramie plains. We passed over the different beds of the cretaceous period for about 30 miles, until we reached a point near Cooper's creek, when indications of the tertiary begin to overlap the cretaceous.

The examples of the erosive action of water along the northern side of the mountains that border the Laramie plains are numerous. In the valley of Cooper's creek near the foot of the mountains there is a triangular space about five miles long, and two or three miles wide on the south-west side. On the south side there is a hill 500 feet high, the summit of which is composed of drift, and the surface paved with partially worn rocks. On the north-west side there is a long ridge, the top of which is composed of the yellowish sandstones of cretaceous formation No. 5, in which a few characteristic species of fossils, like *Inoceramus*, occur. These ridges seem to converge about two miles below the Stage Station, so that the creek passes through a sort of gorge. The valley of the creek is covered quite extensively with drift materials derived from the neighboring mountains.

Six miles west of Cooper's creek we find the first good exposure of coal. The upper cretaceous beds crop out occasionally in that vicinity, but are overlapped by the coal bearing strata.

The slopes are all so gentle and the superficial drift covers the country to such an extent that I found it difficult to get a good section. No. 5 (cretaceous) seems to pass gradually up into the coal-bearing beds, and the change in the sediments of the two systems is slight.

What appears to be the lowest bed of the coal-bearing series in this region, is a brown grit, very loosely aggregated with, sometimes, irregu-

lar layers of sandstones; at other times inclosing concretions, with concentric layers or composed of thin laminæ and readily cleaving in pieces on exposure to the atmosphere. Immediately underneath the coal lies a bed of drab clay varying in thickness from three to five feet. The first locality where the coal is exposed by the uplifting of the beds is near a small lake. The dip is about 10° towards the north-east and from the mountains. There is about six to eight feet of pure and impure coal together. Above, is a bed of drab clay; and over this again a layer of fine grit, capped with hard sandstone. The clay over the coal is full of small rounded nodules of iron and yellow sandy concretions.

About a mile west from this locality is another outcropping of coal. The bed is here separated by about 2½ feet of drab arenaceous clay, with five feet of excellent coal above and six to eight feet below, making in all from ten to twelve feet of solid coal. Some of it has a dull bituminous look, other portions are as glistening and black as anthracite. Above the coal is the usual clay bed, many layers in which are largely composed of the stems and leaves of plants. Above this there are beds of loose rusty brown sand and sandstone with some ferruginous concretions; and a layer of light brown very compact silicious rock caps the hill. The dip of the beds is not more than 3° to 5°. At the immediate entrance to the mine the inclination is about 5°. The coal can be easily wrought and the mine well drained, in spite of its clay roof. The coal is of excellent quality, but like most of the brown coals of the west, crumbles on exposure to the atmosphere, as appears from the condition already of the large coal heaps in front of the mine.

So far as I have been able to ascertain, I am inclined to believe that the coal bed already alluded to is the lowest in the region and identical with the one so successfully worked at Carbon Station on the line of the Union Pacific Railroad; but I do not think that it is the oldest coal bed in the tertiary series of the West.

The valley of Rock creek is from three to five miles in width and evidently a valley of erosion. On the west side of it there is a ridge at least 500 feet high, composed of tertiary beds, which in some places incline 10° to 15°, but the general dip is not more than 5°.

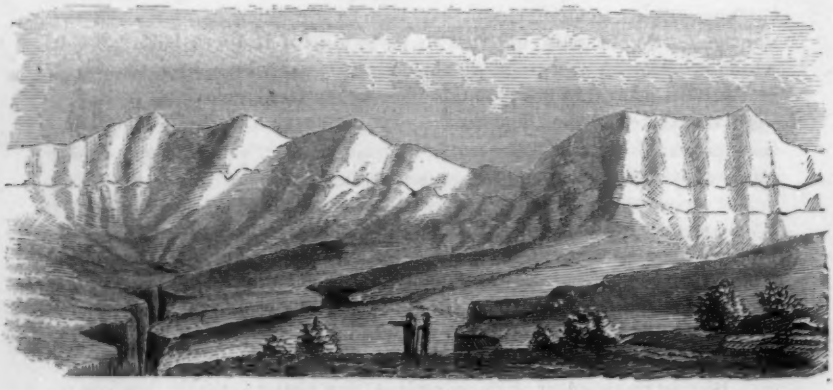
On both sides of the stage road for ten miles west of Rock creek there is a large area covered with huge piles of rusty brown sandstone, mostly concretionary. In some localities a great many impressions of deciduous leaves were found. The tertiary beds extend to the mountains and form a large part of the foot hills. Here lofty wall-like exposures of sandstone make their appearance, giving a very rugged appearance to the country. As far as the eye could reach we saw peculiar looking pyramidal, conical and dome-shaped hills, from 300 to 500 feet high, composed of alternate layers of rusty yellow sandstone and greenish gray indurated sands, which are sometimes in the valleys of streams exposed for a thickness of 1000 or 1500 feet. These beds incline gently from the mountains, about north-east.

Since crossing the Big Laramie river exposures of the red beds have not

been observed in the foot hills of the mountains. Usually they form a most conspicuous feature in the scenery. Their absence here is due either to the comparatively small erosive action, insufficient to wear away the cretaceous and tertiary beds; or to the fact that they are covered with a thick deposit of drift. The inclination of the beds are gentle and the ascent of the mountain side is as it were by steps; one series of foot hills rising slowly above another, until the snow capped ranges are reached. In this region all the hills, and even the gorges through which the little streams flow, are so covered with debris and the whole surface is so clothed with grass, that the rough points are smoothed down and the underlying rocks are difficult to see. Even Elk mountain, which must rise at least 1500 feet above the bed of Medicine Bow creek, is so smooth and so covered with grass, that the rocks are nowhere visible.

North of the road for 30 miles or more, the tertiary beds are on the contrary worn by atmospheric agencies into a great variety of rugged forms, so that the scenery recalls portions of the "Bad Lands" on the Upper Missouri composed of the same formations. Fig. 1 illustrates the character of the coal-bearing formation of the Upper Missouri, but is equally descriptive of the region under notice. The feature of greatest interest is that which affords evidence of comparatively recent glacial action, not merely in valleys of erosion, but in vast deposits of water-rolled rocks, everywhere visible. The mountain sides toward the plains are literally paved with rounded boulders, commonly of no great size; but the sides of the hills opposite the mountains, have scarcely any on them, and are in most cases covered with bushes or with grass. The bottoms of the streams are also covered with pebbles or boulders; and the nearer the mountains the larger and more numerous these rocks become.

FIG. 1.



The Medicine Bow creek, a fine mountain stream fringed with a considerable belt of cotton-wood, has a valley extending far into the mountains, with a gradual ascent. It is by far the most beautiful valley west

of the Laramie river. Although covered thickly with boulders the soil is good, and the grass excellent. It has been for years a favorite pasture ground.

Elk mountain is a short range of spurs with its highest point fronting the creek; it resembles the short range, with abrupt front, east of the Little Laramie. The metamorphic rocks have been uplifted, while the unchanged rocks have remained quiet, or been let down at the foot of the mountain, without leaving that series of upheaved ridges which we find running along the base of most of the mountains. The range is about 10 miles long, forming what I have called an abrupt anticlinal; that is, on one side of the mountain the anticlinal is complete, the unchanged rocks inclining *from* the mountain in regular order of sequence; while on the mountain side the rocks are nearly vertical, and the sedimentary beds jut up against the base, their edges being entirely concealed. Against the north side of Elk mountain the cretaceous and some of the tertiary beds jut so abruptly that all the older rocks are concealed, while on the opposite side, the entire series, from the granite nucleus to the cretaceous formation, may be measured across their upturned edges.

Along the immediate base of the mountains there is a belt of country which in many instances might be called a monoclinal valley. It has been even more smoothed by erosion than any of the valleys of the streams, and always runs at right angles to them. Through this valley of erosion the old stage road and Western Union Telegraph line is located.

North of the road can be seen a series of upheaved ridges somewhat irregular in their continuity but gradually receding northward like sea waves. The first ridge is composed of a series of dark brown indurated clays and sands, with layers of more or less laminated rusty sandstone of fine texture, and tendency to concretionary forms, varying rapidly in thickness from 2 to 10 or 12 feet, dipping N. 20° W. from 5° to 10°, 20° west of north. In this ridge are quite extensive beds of lignite, one of which is about six feet thick separated into three parts by layers of clay. In the harder layers above and below are great quantities of indistinct vegetable impressions. The interval between the first main ridge and the second is about 1½ miles, and in that interval several lignite beds crop out with layers of light gray fine grained siliceous rock.

The second main ridge is composed of a variety of beds inclining 3° to 5°, the general color being brown, or light drab, while the harder layers are rusty sandstones. One bed, perhaps 50 feet thick, is of fine gray indurated sand with a greenish tinge. At the summit of this ridge were very distinct indications of the lignite bed at some period in the past. Several feet of rocks were baked to a brick red color, and fragments of completely fused rock lay scattered about. From the bed of the Medicine Bow to the summit of the second ridge I estimated that 1200 to 1500 feet of strata were exposed to view, and from the presence of lignite and deciduous leaves I regarded them all as belonging to the tertiary series. Some of the sandstones are made up of an aggregate of crystals of

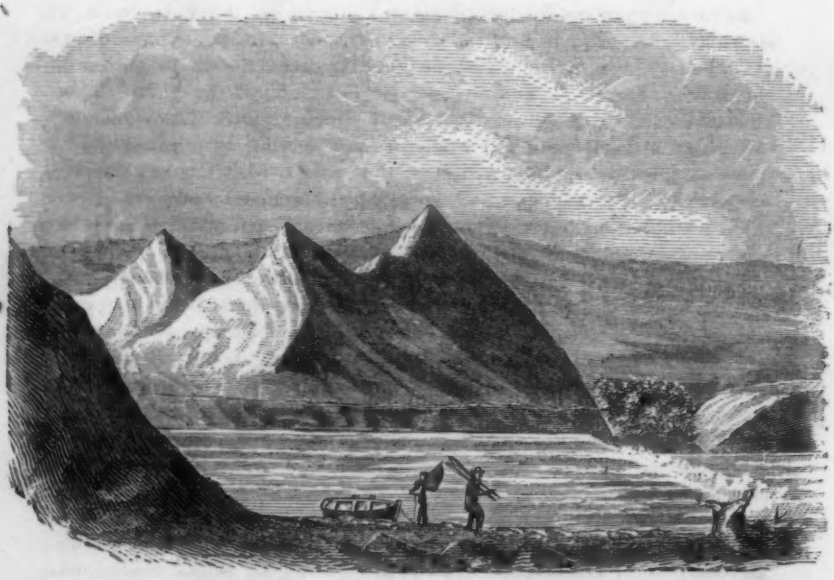
quartz and feldspar, showing that the materials were derived at least in part from the metamorphic rocks. Many of these sandstones disintegrate by exfoliation, or exquamation, and have the rusty spherical concretions scattered through them.

The main trend of these ridges is N. E. and S. W. The general appearance of the country is extremely desolate and cheerless; scarcely any vegetation but sage and grease-wood; with here and there a little lake, which from its alkaline character only adds to the dreariness of the scene.

Near the summit of the second ridge in the burnt rocks are quite abundant impressions of plants; and more especially lower down, about the middle of the ridges, there is a layer of the iron rocks about 2 feet in thickness largely composed of fragments of leaves.

A few miles west of Fort Halleck a very conspicuous hill, called Sheep mountain, is composed of carboniferous limestones, red beds; and is probably capped with lower cretaceous rocks. These beds incline 25°, but a very hard bed of sandstone capping the summit dips 35°. There appears to be an unusual thickness of triassic (?) rocks at this locality. The average dip of the strata is from 30° to 50°, varying between west and north.

FIG. 2.



From Medicine Bow river to Rattle Snake Pass, a distance of about 30 miles, the road extends through a monoclinal valley.* For nearly our

* Fig. 2 illustrates the character of the upheaved ridges which everywhere are seen upon the margins of the mountain ranges, extending in many cases for miles, like waves; and the geologist can walk across the upturned edges of all the formations from the granite to the most recent tertiary inclusive.

entire route the road seems to form the line of separation between the cretaceous and tertiary rocks, the former being well displayed on our left, jutting up against the mountain sides; the latter extending in wave like ridges into the distance on our right. As we approach Pass creek however about 5 miles to the east, the cretaceous beds reveal themselves clearly on the right side of the road, No. 5 attaining a great thickness; while, on the left, inclining from Sheep mountain Numbers 3 and 2 are very plainly shown in a series of irregular and rather low ridges. All along Elk mountain the red beds are visible but not conspicuous, and they do not give color to the debris at the foot of the hills. In this vicinity the tertiary beds must be at least 5000 feet thick, which, with an equal thickness of the cretaceous, makes in all at least 18,000 feet, a larger development than I know at any other point to the eastward. Indeed we shall be able to show that these formations continue to increase in thickness as we go west.

On the north side of Pass creek we have an uplift of rather fine grain yellow sandstone, which presents a front like a wall composed generally of vertical columns. On the summit are isolated piles of every form, the relics of erosion. The sandstone is about 200 feet in thickness and the ridge inclines northward at an angle of about 19°. The trend of all these ridges varies between north and west.

As we emerge from the hills through the Pass on the Pass creek, we strike a vast open plain, and the ridges of upheaval seem to pass off and die out en echelon in the plain, the ends making a gentle flexure from the west northward, so as to form one side or rim of the plain. There appears to be in these formations many alternate beds of brownish yellow sand and sandstones, the whole readily yielding to atmospheric influences, covering the hills as well as the valleys, with a great depth of fine sand, from which the long lines of harder sandstone project. These ridges of upheaval run at various distances from each other, from 100 to 1000 yards, with monoclinal valleys intervening.

The broad plain west of Elk mountain must be a region of depression; or a portion of the country left undisturbed while the surrounding parts were elevated. As far as the eye can reach this plain appears to be perfectly level; and no cuts to show the character of the underlying beds. A thick deposit of drift covers every thing. On its northern side the mountain ridges seem to trend about north-east and south-west, the southern end sloping gently down with the plain. The rusty calcareous sandstones which form the inner ridges facing the plain are undoubtedly cretaceous and incline 30° to 45°. These rusty sandstones here form a belt about 1½ miles in width, with intercalated layers of yellow arenaceous material covered with grass, only the harder layers projecting here and there above the surface. In one of these higher ridges of sandstone a Baculite (*B. ovatus*) was found. In another ridge was a seam about six inches in thickness composed entirely of a small oyster about the size, "though probably distinct from" *O. Congesta*. In the plain country,

even far distant from the mountains, the rocks are more or less disturbed, but generally not exposing older beds than the cretaceous.

We find also that there is an irregular series of anticlinals and synclinals resembling somewhat, but on a gigantic scale, the furrows in a ploughed field. Not unfrequently we meet with a high synclinal ridge, formed of rocks inclining toward each other; and then following the same beds along and across the ridges we shall find them dipping away from each other making a synclinal valley.

I have given my observations along this route somewhat in detail from the fact that no accurate information concerning the geology of this region has ever been published; and because we have had no definite data for coloring a geological map. Our course was along the Overland Stage Road just at the base of the mountains, on the south side of the Laramie plains, from 5 to 20 miles south of the Union Pacific Railroad line; and by comparing my observations of the geology along the stage road with those along the line of the railroad it will be seen that there are many points of difference. As I have before remarked, the Laramie range of mountains forms one of the most complete and beautiful anticlinal systems in the West.

The Laramie plains, as the area enclosed by these mountains is called, exhibits a broad, undulating almost treeless, surface about 60 miles long from East to West, and 50 miles broad from North to South. From Fort Sanders along the stage route to Little Laramie river, the distance is about 18 miles. The surface is quite undulating, but all the slopes are moderate in their inclination. All the basis rocks belong to the cretaceous period. At the crossing of the Big Laramie may be seen a small thickness of the black clays of No. 2, and here and there are isolated hills which show the yellow chalky layers of No. 3. Some of the higher ridges which extend down into the plains from the foot of the mountains reveal here and there the rusty yellowish arenaceous marls of No. 5.

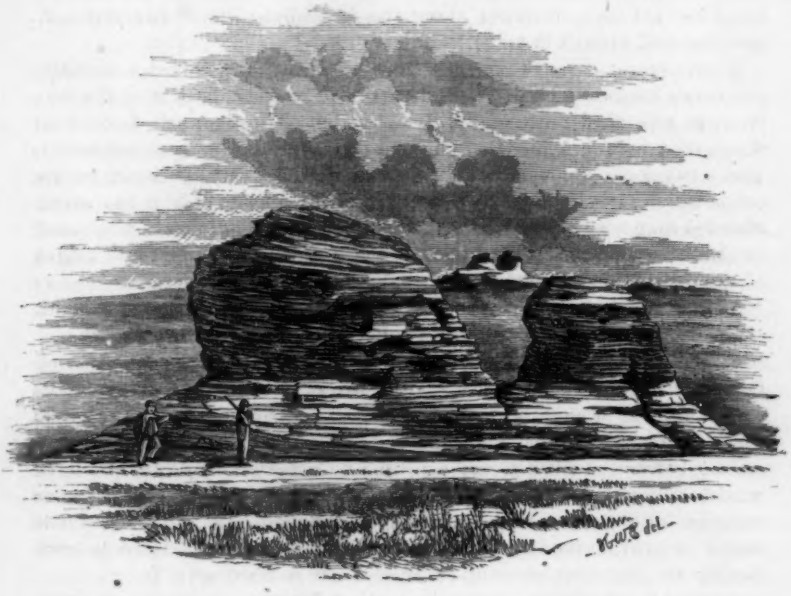
From Little Laramie Station to Cooper's creek the distance is 15 miles. Over this interval the cretaceous rocks prevail and belong mostly to the upper portion of that period. There are probably isolated patches of tertiary overlapping the cretaceous beds. One of these isolated areas of tertiary occurs about two miles north of Cooper's Creek Station on the west bank of the creek where an excellent coal bed has been opened nine feet thick. The coal is quite pure, compact, but rather light, and burns well. I do not think it will be continuous over a very large area, but it will yield a large amount of fuel before it is exhausted.

From this point westward nearly to Fort Bridger, and perhaps beyond, the tertiary beds may be said to prevail in the plain country. Rocks of older date with comparatively few exceptions are not seen except in close proximity to the mountains. In some instances the mountains abut abruptly on the plains, the tertiary or cretaceous beds jutting against the granite or igneous nucleus, and concealing for long distances all the older rocks. Again, intervening between the plain country and the principal mountain ranges are 50 to 100 miles of what may be called

foot hills, or minor ranges of the mountains, in which are exhibited on a grand scale the entire series of unchanged rocks known to exist in this country.

In the mountains near the sources of the Little Laramie the red beds show themselves in very great thickness and give to the scenery peculiarly picturesque features.* Near Elk mountain the red beds appear again; but in the interval they seem to be partially concealed either by drift or cretaceous and tertiary beds. It will be impossible to represent minute details of the geology of this country by colors except on a carefully prepared topographical map constructed on a much larger scale than any that we have. We are satisfied, however, whether the older formations are well shown or are concealed entirely, or in part, that they either do now or did once extend across the country with a nearly uniform thickness.

FIG. 3.



We will now return to Laramie City and examine the geological character of the country along the line of the Union Pacific Railroad westward. From Laramie City to Cooper's Lake Station, a distance of 25.6 miles, there is a good degree of uniformity in the character of the coun-

* The action of the atmosphere upon these brick red sandstones of the Triassic Age is beautifully shown in the wood cut, Fig. 3, taken from a photograph. These worn sandstones form a conspicuous feature in the scenery of the Laramie Plains.

try. On our right the Laramie range appears like a wall bending round to the north-west and west, and finally disappearing from view at Cooper's Creek Station. Near the crossing of the Big Laramie river we see on our right the red beds which are somewhat marked. We can follow them up to the foot of the mountains by their peculiar brick red color. Then come the cretaceous rocks, especially the upper members of the group, soon after crossing the Laramie river, and continue to a point about 5 miles east of Como Station, more than 60 miles west of Laramie City. There may be some few isolated patches of the tertiary beds. The principal rocks seem to belong to No. 5.

Carmichael's Cut east of Rock Creek is a locality quite well known. The strata cut through are mostly rather friable fine grained rusty gray sandstones, with bluish brown calcareous concretions of various sizes scattered through them, which when broken open reveal a great variety of shells—Baculites, Ammonites, Inoceramus, and many other species characteristic of No. 4 and 5, which undoubtedly blend throughout this region, and cannot be separated as distinct divisions of the system. No. 3 has not been observed along the immediate line of the railroad, but it is well showed in many localities in the Laramie plains.

From Laramie City to Cooper's Station the country as far as the eye can reach presents a cheerful appearance. The irregularities of the surface are smoothed down and a long stretch of level prairie is covered with grass, with here and there a grass covered ridge or rounded butte. The basis rocks are mostly indurated arenaceous clays or loose yellow sands which yield readily to atmospheric influences. There are many rounded arenaceous concretions, and sometimes a thin layer of laminated sandstone. There is a slight disturbance of the beds; and the ridges of upheaval seem to trend nearly east and west.

As we proceed westward from Cooper's Station we find the black clays of No. 2, and the appearance of the country becomes dreary and sterile in the extreme. They extend to a point about 5 miles east of Como. The waters are alkaline, and there is no timber along the creeks except stinted willows, and very little grass or vegetation of any kind; as far as the eye can reach nothing but black plastic clays.

Just before reaching Como we come to a very interesting quarry of sandstone from which the materials for the construction of the extensive railroad buildings at Laramie City and Cheyenne are obtained. The rock is a gray, rather friable, sandstone, and occurs in isolated patches resting on the shaly clays of No. 2, and are so filled with fragments of vegetable impressions, sometimes quite distinct deciduous leaves, that one is reminded of the tertiary sandstones. I am inclined to think however that it is a local deposition of sandstone in the cretaceous series. This point and the district about Como is extremely interesting to the geologist, and there are some curious problems yet to be solved.

At Como Station the railroad runs for some distance through a distinct anticlinal valley, the strata inclining away to each side. The south side of the road exhibits the most complete series of the beds. A high ridge

is composed of jurassic beds mostly capped with the sandstones of No. 1, while as far as the eye can extend southward the low wave like ridges of No. 2 can be seen. Towards the southwest the anticlinal valley seems to close up, but north-eastward expands indefinately, and extends no doubt to the Laramie mountains. In the valley the red arenaceous beds are quite conspicuous.

These jurassic rocks are composed for the most part of alternate layers of loose sands and some harder beds of sandstones, but there are a few layers of sandstone and marl; and in these are great quantities of an *Ostrea*, *Pentacrinus*, *Asteriscus*, and *Belemnites densus*, all well known jurassic types.

These beds throughout the jurassic series are full of tidal ripples, mud markings and irregular laminæ of deposition, indications of a shallow water deposit. All the fossils are badly broken and worn as if they had been transported from a great distance and deposited in turbulent waters. About a mile west of the station the road cuts through the full series of jurassic beds with Nos. 1 and 2 of the cretaceous inclining north-west at an angle of 45° to 50°.

From a point about 10 miles east of Como to St. Mary's Station, for a distance of about 50 miles, the tertiary formation occupies the country with the sands, sandstones and clays peculiar to it and also numerous coal beds. The most marked development of the coal beds is at Carbon Station, about 80 miles west of Laramie Station. The rocks incline nearly south-east or south and east. Three entrances have been made to mine a bed 9 feet thick. The openings follow the dip and consequently descend. The mines are about 300 yards from the railroad; a side track has been laid to them. More than 1000 tons of coal have already been taken out, and the Union Pacific Railroad Company are ready to contract for any amount that can be supplied. The coal at Carbon is of the best quality of tertiary splint, very compact and pure. It is not as hard as anthracite, but the miners informed me that it was more difficult to work than the bituminous coals of Pennsylvania. It is used to a great extent on the locomotives, and the engineers speak in high terms of it. Over the coal is what the miners call slate, a somewhat earthy bed breaking into slabs showing woody fibre, and much of it looking like charred wood or soft charcoal. As we pass up in the section fragments of deciduous leaves are seen more distinctly, and finally the whole graduates into a dark drab clay. At the bottom of the coal are thousands of impressions of deciduous leaves, such as *Populus*, *Platanus*, *Tilea*, &c. Some of the layers of rock, 2 to 4 inches in thickness, are wholly composed of these leaves, in a good state of preservation, and so perfect that they could not have been transported any great distance.

The Union Pacific Railroad Company have placed their coal interests in charge of Mr. Thomas Wardell, an old English miner, who is constantly employed in prospecting and opening mines the whole length of the road. At Carbon he has erected six pretty cottages, as residences for the miners, and a number more are in process of building. At

Separation and Point of Rocks other villages will be built. All the apparatus for permanent and extended mining operations are being gradually introduced. Nearly all the wood now along the line of the road has to be transported from 10 to 40 miles, and in two years from the present time most of it within a reasonable distance of the road will have been consumed. The future success of this great thoroughfare is therefore wholly dependent on the supply of mineral fuel, and its importance cannot be too highly estimated.*

From St. Mary's to Rawlings Springs, a distance of about 30 miles, the railroad passes over rocks of cretaceous age. No coal beds need be sought for in the immediate vicinity of the road, although it is quite possible that on the north side of the road isolated patches of tertiary containing coal may be found. The railroad from a point about 8 miles east of Benton to Rawlings Springs, passes through one of the most beautiful anticlinal valleys I have seen in the West. On either side the rusty gray sands and sandstones dip away from the road at an angle of 10° to 15°. This anticlinal valley is most marked near Fort Steele at the crossing of the North Platte.

About 5 miles east of Fort Steele I made a careful examination of a railroad cut through a ridge of upheaval which inclined about south or a little east of south. We have, exposed here, commencing at the bottom:

1. Gray fine grained sandstone, rather massive and good for building purposes and easily worked, 80 feet thick—dip 25°.

2. A seam, 2 feet thick, of irregular black indurated slaty clay, with layers of gypsum all through it then 2 feet of aranaceous clay.

3. Ten feet of rusty gray compact sandstone.

4. Eight feet of clay and hard arenaceous layers, very dark in color, passing up into harder layers which split into thin laminæ, the surfaces of which are covered with bits of vegetable matter.

5. About 50 feet of rusty yellowish gray sandstone. All these sandstones contain bits of vegetable matter scattered through them.

6. 100 to 150 feet of steel-brown indurated clay with some iron concretions. The clay is mostly nodular in form.

7. A dark brown arenaceous mud rock, quite hard, 30 feet.

From bed 5 I obtained numerous species of marine shells, among them a species of *Ostrea* and *Inoceramus* in great numbers. The upper surfaces of the hard clay layers appeared as though crowded with impressions of sea-weeds or mud markings. In another railroad cutting about 4 miles

* Mr. J. P. Carcou, an assistant on the survey, made an analysis of a fair specimen of the coal from the Carbon mines with the following result:

Moisture at 100° C.	11.60.
Volatile Combustible Matter,	27.68.
Fixed Carbon,	51.67.
Ash,	6.17.
Sulphur,	2.88.

Color of Ash, light grey.
Specific gravity, 1.37.
Weight, per cubic yard, 2212 lbs.

east of Rawlings Springs I obtained the same *Inoceramus* and a large species of *Ammonite*. These fossils are important in establishing the age of these rocks.

At Rawlings' Springs are some very interesting geological features. At this locality the elevatory forces were exerted more powerfully than at any other point along the railroad from Laramie Station to Green river. The entire series of rocks are exposed here, from the syenites to the cretaceous inclusive. The railroad passes through an anticlinal opening. To the south of the road are variegated gray, brown and reddish siliceous rocks dipping 5° to 10° S. W. A very hard bluish limestone resting upon them I have no doubt is carboniferous, although I was unable to find any fossils in this region. North of the road ridges of upheaval stretch away toward the north-west and attain a height of 1200 to 1500 feet above the road. On careful examination the red syenite may be found exposed in a number of places, and gives us the opportunity of studying the relation which the unchanged rocks sustain to the metamorphic. The syenite beds dip 70° about S. E., the unchanged beds resting upon them in nearly a horizontal position. The layers immediately on the syenite are a beautiful pudding stone of rounded quartz pebbles and feldspar, and above it layers of fine siliceous rock with thin intercalations of clay, the whole having the position and appearance of Potsdam sandstone. I am inclined to believe that we have here lower silurian representatives. In all cases these rocks repose on the upturned edges of the syenite; sometimes nearly horizontal; again inclining 3° to 10°. In one or two places these lower silurian (?) beds are lifted a thousand feet or more into the air, still maintaining a nearly horizontal posture. On the mountain sides the beds are broken off so as to incline 50°, 60°, up to nearly 90°.

These siliceous rocks, covered with ripple marks, &c., afford excellent building stone, and are much used by the railroad company. They reach a thickness of 500 to 800 feet. Upon them rests the blue limestone, 30 to 40 feet thick; then variegated sandstones; and the red beds in the distance.

From the tops of these ridges one can see numbers of both synclinal and monoclinal valleys. There is one monoclinal valley, 3 to 5 miles wide, which stretches far into the north-west, a smooth and level grassy prairie. All these ridges have suffered great erosion, and the silurian (?) beds are planed and grooved even to a greater extent than the more recent beds. Everywhere the evidences of erosion during the drift period are on a gigantic scale.

A fine sulphur spring from under the bed of blue limestone gives name to the station. The water is clear and possesses excellent medicinal properties.

About 4 miles west of Rawlings' Springs the tertiary beds begin to overlap, but in the distance on either side are lofty ridges of cretaceous and perhaps still older rocks. The ridge, 15 miles south of Separation, at least 1000 feet high, is certainly formed of lower cretaceous and prob-

ably also of that great thickness of sandstones and clays which hold a position between the transition No. 1, and the brick red beds.

Near Separation, about 10 miles west of Rawlings' Springs, a coal bed 11 feet thick has been opened, probably the same as the one opened at Carbon, and near Rock and Cooper creek. The dip is nearly west about 10°. The opening being at the summit of the hill, all the coal will have to be drawn up a slope, and the difficulties of drainage will be greatly increased. The coal is of excellent quality. Above and below the coal is the usual drab indurated clay. Below the clay is a bed of gray ferruginous sandstone.

On the summits of the hills in the vicinity are layers of fine grained siliceous rocks with arenaceous concretions, some of them containing impressions of deciduous leaves.

The tertiary beds lie in ridges running across the country. The beds are uplifted in every direction. A more desolate region I have not seen in the West. Nothing seems to grow but sage bushes, and in some of the valleys they grow very large. All over the surface of the hills and in the plains are great quantities of water-worn pebbles. Many of these valleys were scooped out by an amount of waters far in excess of any known at the present day in this region. Some of the widest and deepest do not now contain any running stream.

The layers of fine grained sandstone on the hills in this vicinity contain more or less impressions of leaves, like *Populus* and *Platanus*, in a good state of preservation.

West of Separation the dip of the tertiary beds diminishes. Before reaching Creston, about 13 miles west of Separation, they lie nearly horizontal, and all the surrounding country presents more the appearance of a plain. At that station the Union Pacific Railroad Company have a well 100 feet or more deep, at a depth of 83 feet in which was struck an 8 foot coal bed, with 4 feet of excellent coal and 4 feet of coaly shale. The coal was of about the same quality as that near Separation, probably from the same bed. If so, coal at a depth of about 80 feet must underlie an area of at least 100 square miles. In this well beds of bluish arenaceous clay were passed through first, then black clay with carbonaceous matter throughout. Just over the coal was fine bluish indurated clay with very distinct impressions of leaves, among which the most abundant were *Populus* and *Platanus*. The railroad cuts and the valleys themselves show very distinctly the character of the intermediate softer beds. The erosion has been so great in this country, and all hills and cañons are so covered with debris that it is almost impossible to obtain a clear idea of the color and composition of the intermediate softer beds. The harder sandstones, &c., project from the surface and are accessible to the eye without much excavation. Marine and fresh-water tertiary formations occupy the whole country along the line of the railroad to Quaking Asp Summit, west of Fort Bridger, and possibly over to Salt lake to a greater or less extent.

From Creston to Bitter Creek Station, a distance of 45 miles, the beds

are mostly fresh water and hold a nearly horizontal position. West of Bitter creek we get again upon marine tertiaries dipping 3° to 6° nearly east. We have therefore between Rawling's Springs and Green river a sort of synclinal basin, the marine tertiary dipping west about 10° on the east side, and the same marine beds inclining east 3° to 6° on the west side; while at Table Rock, Red Desert, and Washakie, a considerable thickness of purely fresh water beds are filled with shells of the genera *Paludina*, *Unio*, *Melania*, &c.

Table rock is a square butte lifting itself about 400 feet above the level of the road, composed of the beds of a sandstone which in many instances is little more than an aggregation of fresh water shells.

After leaving Bitter Creek Station the hills approach nearer to the road and show the characteristic features of the marine tertiary again. Seams of coal appear in many places, while yellow arenaceous marls, light gray sand with indurated clay beds and more or less thick layers of sandstone occur. The dip varies from 3° to 6° east or nearly east.

At Black Bute Station on Bitter creek, about 15 miles west of Bitter Creek Station there is a heavy bed of yellow ferruginous sandstone, irregular in its thickness and in part concretionary, and full of rusty concretions of sandstones of every size from an inch to several feet in diameter, mostly spherical, and when broken revealing large cavities filled with oxide of iron loam. This sandstone, 150 to 200 feet in thickness, forms nearly vertical bluffs, and is worn by atmospheric agencies into the most fantastic shapes. Above it are sands, clays, sandstones of every texture and coal beds, one of which, near the summit of the hills, has been burned, baking and melting the superincumbent beds. I found in several layers the greatest abundance of deciduous leaves, and among them a fine Palm leaf, probably the same species which occurs in the coal beds on the Upper Missouri, named by Dr. Newbury *Campbelli*. There is also a thin seam near one of the coal seams made up of a small species of *Ostrea*.

The railroad passes down the Bitter creek valley which has been run through the tertiary beds, and on each side high walls can be seen inclining at low angles. As we pass down the valley toward Green river, the inclination brings to view lower and lower beds. These are all plainly marine tertiaries, while an abundance of impressions of plants are found everywhere. No strictly fresh water shells occur, but seams of *Ostrea* of various species. There are also extensive beds of hard tabular rocks which would make the best of flagging stones. On the surface are excellent illustrations of wave ripple marks, and at one locality tracks of a singular character; one looking as if it had been made by a soliped. It resembles the tracks of mules on the soft bottom ground. Others seem attributable to some huge bird; another to some four-toed Pachyderm. I obtained specimens and careful drawings of these tracks.

In the field report some detailed sections of these tertiary beds will be given. Yet I am convinced that local sections are not very important. The character is so changeable that two sections taken ten miles apart would

not be identical, and in some cases not even very similar. The more recent the age of formations the less persistent seem to be their lithological characters over extended areas.

Although the coal beds seem to be abundant everywhere along the line of the road in the lower tertiary deposits, they have been wrought as yet in few localities. Near Point of Rocks Station, about 45 miles east of Green river, one of the best coal mines I have yet seen in the West has been opened, and Mr. W. Snyder, the able Superintendent of the Union Pacific Railroad, has ordered a side track to be laid to it about a quarter of a mile long. Five coal beds have been opened in a vertical height of 80 feet. The lowest is about 100 feet above the bed of the creek. They are respectively 5, 1, 4, 3 and 6½ feet thick. The five foot bed is the most valuable, and as the strata are nearly horizontal it can be worked with ease and free of water. The hard, compact coal is pitched down the sides of the hill more than a hundred feet without being broken by the fall. It is purer and heavier than any coal I have yet seen west of the Laramie mountains. The other beds already opened will yield moderately good coal. Several other beds are in these hills which have not yet been examined. Near the summit of the hills, above the coal beds, there is a seam six inches thick composed entirely of oyster shells, about the size of the common edible oyster, but of a distinct and probably undescribed species.

Another bed of coal has been opened about 28 miles west of the Point of Rocks, at Rock Spring. It is about 4 feet thick, with a bed of sandstone at the bottom and a slaty clay roof. It cannot be worked to advantage.

Scattered all through the coal-bearing strata are seams and concretions of brown iron ore in abundance, sometimes persistent over extensive areas, and varying from 4 to 12 inches in thickness. The ore occurs mostly however in a nodular form, and much of it can be made of economical value when there is a demand for it. There are also numerous Chalybeate and Sulphur springs with excellent medicinal properties.

Near Rock Springs fresh water beds again incline nearly west 6° to 10°, but apparently different from those between Creston and Bitter creek.

The beds exposed at this point are made up of drab clays, sometimes a little sandy, with heavy beds of gray and rusty yellow easily disintegrating sandstones. There are also in the clay beds quite thick beds of coal which have ignited spontaneously and baked the superincumbent layers, in many cases melting the rock. There is very little vegetation on these hills, only now and then a dwarf cedar.

Near the summit of the hills there is a thin layer of limestone composed of an aggregate of small *melanias*.

From Rock Spring to Bryan the rocks present a peculiar appearance, occurring mostly in thin laminæ or layers like slate. There are 300 to 500 feet of these drab gray laminated shales, and above them, capping the hills about Green river, are from 300 to 500 feet of rusty yellow shales, which are weathered into castellated forms.

Near the junction of Bitter creek and Green river there is a bed of very singular bituminous earth which has excited much attention. It has been used as a fuel and burned so readily in stoves, that some people valued it more than true coal; but it is not now much used. An analysis shows that it is an inferior fuel.* The bed is usually about 4 feet thick, but sometimes only 2 or 2½. It is often parted by several thin seams of shale. These Green river shales or slates as they might be called, must contain some calcareous matter, although not very fossiliferous. Possibly a more careful study will reveal a greater variety of animal and vegetable forms.

In the same cuts between Green river and Bryan, a distance of about 13 miles, great quantities of fossil fishes occur in a kind of chalky slate. Quite perfect impressions are formed upon the surfaces of the slates, presenting the appearance of having been preserved in quiet waters. Indeed all the Green river rocks may be said to possess a soft chalky character. At Bryan some fine specimens of fish were obtained from a well about 60 feet below the surface.

On the distant hills of this locality are layers of a chalky limestone which would make excellent lime and is now used as a building stone. It has the appearance of oolite, and in fact is made up of an extinct undetermined species of *Cypris*. About 7 miles west of Bryan we have:

4. Yellowish chalky laminated beds, very thinly divided.
3. Thin layers of gray chalky limestone filled with fresh water shells like *Corbula*.
2. Rusty indurated sandstone, somewhat shaly.
1. Gray shale.

Many of the layers in bed No. 3 are made up almost entirely of a small bivalve shell.

About 2 miles above Green River Station the river cuts through a great thickness of fine sand and gravel showing, on the slope and bottoms a vast deposit of drift. Much of the shale in this region has a greenish tinge, and the river in passing over them seems to have taken up some of the green coloring matter, so that the water has a peculiar green color and hence the name.

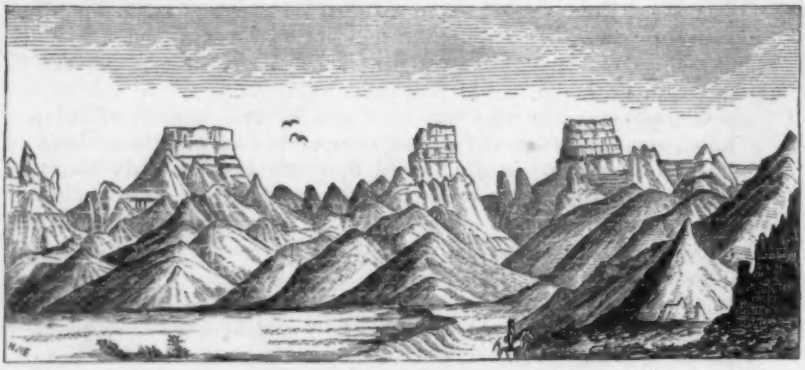
From Bryan to a point about 10 miles west of Fort Bridger the entire surface of the country is covered with buttes of every shape, cones,

* Mr. Carson's analysis of a specimen of this bituminous earth gives the following constituents:

Silicic acid,	18.58.
Sulphuric acid,	3.88.
Sesquioxide of Alumina,	8.14.
Sesquioxide of Iron,	2.19.
Lime,	14.11.
Magnesia.	7.11.
Carbonic acid,	17.40.
Water,	2.90.
Volatile Matter,	22.25.
Fixed Carbon,	3.73.
	100,29.

pyramids, and long ridge-like hills which show a vast amount of erosion. Indeed the portion about Church Butes is precisely like the Manvaises-terres or Bad Lands of White river.*

FIG. 4.



In a cut along the railroad nearly opposite to Church Butes there is a bed formed of clay filled with small kidney shaped masses of fine bluish clay, the whole filled with beautiful specimens of *Unios*, *Paludinas* and other fresh water shells. There are also in the same cut layers of greenish clay much indurated, flesh colored concretionary and rusty drab sandstone.

About 6 miles west of Carter's Station a cut in the road reveals a tough plastic dark gray clay, and at the top of the cut a bed of flinty concretions filled with small seams of chalcedony. The whole country is paved with small water worn pebbles, mostly of opaque flint and some of them exceeding 4 or 5 inches in diameter. Over a belt about 10 miles wide from east to west and of unknown length from north to south, there are the greatest quantities of moss agates. I am inclined to the opinion that they originated in thin irregular seams in this recent tertiary formation, probably somewhere south of Church Butes. The origin of all this drift is evidently local and it is most probable that the transporting power had its origin in the Utah mountains. These tertiary beds are all nearly horizontal, inclining not more than 1° to 3°.

At South Bend Station there is a layer of silicious limestone filled with small *Melanias*, which are entirely changed into chalcedony. Some *Unios* also occur. The bed below it is composed of ashen gray shale a little arenaceous; then comes a silico-calcareous layer. Above the shell seam

* The geologist can compare the following illustration of the "Bad Lands" of White river, Dakota, with Fig. 4, which is engraved from a photograph taken from nature, of Church Butes. The peculiar features of the weathered hills in this region bear a striking resemblance to those on White river.

is a great thickness of shale, capped with a kind of conglomerate made up of rounded pebbles and concretions, with here and there a *Unio*. In the south and east, 75 miles distant, we can see a range of snowy mountains, Minetah; and the intermediate country is covered with rugged tertiary bluffs. To the north, 100 to 150 miles away, the Wind River range is visible, and this interval is also occupied by the same rugged hills.

At Church Butes a remarkable undescribed species of turtle was found projecting from the hill sides.

The beds of this basin near Church Butes and Fort Bridger incline to the eastward, but are nearly horizontal, and seem to jut up against the mountain sides with very little inclination. The style in which they have weathered or suffered erosion, their position in relation to the older formations, and the general appearance of the surface, suggest their identity with the White River formations. But they are more arenaceous. I am inclined to the opinion that while they are independent basins they were synchronous.

The western rim of this recent fresh water basin is well defined at Quaking Asp ridge. Everywhere here the examples of erosion are displayed on a tremendous scale, and the rounded water worn boulders almost pave the ground. The west sides of the hills are quite abrupt, and are covered with the worn rocks; while the eastern sides slope gently down in long ridges; showing the direction from which the forces have acted as well as their local character; that they originated somewhere in the direction of the mountains, and by scooping out the valleys, strewed the surface with rocks.

Near Fort Bridger, and west to Quaking Asp Summit, there are in the recent tertiary formations several beds of the reddish grit which give its peculiar variegated character to much of the surface in this part of the West. In the cuts of the railroad are shown numerous beds of brick red and purplish clays and sands. The inclination of the beds just on the western margin of the basin is 3° to 5°. There are 100 to 150 feet of reddish indurated clays, slightly arenaceous, with some light brands, and one or two layers of gray sandstone; above this, 100 feet or more of light gray arenaceous material, with some hard layers of sandstone; then irregular harder layers of sandstone, sometimes concretionary, projecting from the sodded hills, and many of the peculiar features of the scenery are due to their existence.

After passing Quaking Asp Summit westward we come into a region underlaid by a distinct series of formations of older date than those at Fort Bridger, and in many cases nearly or quite vertical. The same dip is again to the westward.

About 20 miles west of Fort Bridger there is a fine soda spring yielding the most delicious water. Judging from a deposit near the spring of what appears to be limestone, the water must hold lime as well as iron, &c., in solution. Probably it will be a place of resort at no distant day.

On Bear river there are several outcroppings of coal. The principal one by the side of the railroad near the station is nearly vertical, en-

closed between beds of drab clay, and separated into two members by a clay parting of from 8 to 10 feet thick. There is probably an aggregate of from 12 to 15 feet of good coal. The dip is towards the northwest 60° to 80°. On the upper side, above the drab clay, there is a bed of rather soft gray sandstone 50 to 100 feet thick. Below, are beds of rusty sandstone, clay, and indurated arenaceous clay, yellowish, drab, reddish and gray.

In a railroad cutting, about a mile east of the coal mine, are 25 to 50 feet of drab indurated clay, covered with 150 to 200 feet of ferruginous and gray sandstone dipping north-west. The lowest beds shown here look like cretaceous clays of No. 2; and in some of their slaty layers are an abundance of fish scales, a species of small oyster and a shell like an *Inoceramus*. These black plastic clays, are undoubtedly cretaceous and lie below the coal. The strata enclosing the coal are evidently marine, for all the organic forms thus far discovered seem to belong to marine types. There is also an oil spring in Bear River valley in which parties are sinking a shaft. The whole country exhibits abundant signs of drift action, and the hills as well as the valleys are paved with worn rocks. Between Bear and Sulphur creeks, there is a fine plateau 40 to 50 feet high, covered with sage—*Artemesia tufida*, and as smooth as a table. The soil in the bottoms of the streams is most fertile; if irrigated, vegetables of all kinds grow well, and there is abundance of water for that purpose.

On the right side of Bear river, 10 miles below the station is, Medicine Bute, which must be 800 to 1000 feet high above the bed of the creek. It is undoubtedly composed for the most part of the strata of the coal series, which I am inclined to regard as of older tertiary age, although the evidence is as yet conflicting.

Passing westward from Bear Creek Station, over beds nearly horizontal or inclining at a small angle, we suddenly come to an upthrust of rocks, called the Needles, dipping east or south-east 25° to 35° or 40°. This is a more remarkable exhibition of massive conglomerate than any I have ever seen further east. The rocks project their summits in the shape of sharp pointed peaks to a height from 300 to 500 feet above the road. Some of the worn masses which compose the conglomerate are an aggregation of worn pebbles, proving that a portion of the materials were derived from some still older conglomerate. Sometimes there is a thin local seam of coarse sand containing only a few pebbles, but the whole mass, from 500 to 1000 feet thick, is in the main a coarse conglomerate made up of water worn rocks varying in size from the smallest pebble to boulders a foot in diameter. The pebbles are mostly flint, mixed with a few of sandstone; rocks of modern data being comparative rare. This seems to be a local outburst of the conglomerate through a vast thickness of variegated sands and clays which inclines westward 40° to 60°. The trend is a little west of north. These "needle rocks" are near Yellow Creek Station, and the ridge of upheaval extends down from the Minetah range. In the vicinity of the mountain ranges such

local dips are common, and keep to no regular direction; but far distant from the source of power the ridges are comparatively regular.

From the hills about a mile west of Yellow Creek Station we have the first and most extended view of the country I have ever seen in the West. We can examine objects with considerable distinctness on a clear day for a radius of 50 to 100 miles in every direction, over a most rugged surface, with high ridges and deep gorges, the strata showing red, yellow, gray, and in fact every variety of color. Other beds are composed of quite light colored sandstone.

From Fort Bridger westward one of the most interesting phenomena is the favorable change that takes place in the vegetation of the surface. Broad plains and hill slopes covered thickly with grass, with comparatively little sage, is now the rule. Patches of quaking asp appear here and there and along the streams are fringes of cotton wood.

About 3 miles west of the Needles there is an upheaved ridge carrying a bed of white limestone, with streaks of chalcedony in it resembling those of the White River tertiary limestones, and dipping nearly east at an angle of 20°. After leaving this point the rocks, again nearly horizontal, have for the most part a prevailing reddish tinge, with alternations of reddish indurated clays, and gray and reddish sandstones. The harder layers form quite abrupt bluffs 150 to 200 feet high all along the streams or valleys. In a tunnel at the head of Echo cañon, where the beds have been excavated by the Union Pacific Railroad Company, the base is a red indurated clay, slightly arenaceous, with bands of hard sandstone of a greenish tinge; above this, a red grit, much indurated, but becoming less so as we approach the summit. At Echo Station there are high bluffs of the red grits, with gray sandstones; but the prevailing color of all the rocks in Echo cañon from source to mouth is reddish or dark purple. The excavations for the grading of the railroad are extensive in this region and give a clear idea of the succession of the beds; but there is a great uniformity in the composition of the rocks. The sandstones are gray or yellow, and always yielding readily to the weather, wearing into all sorts of fantastic shapes, full of holes and caves, projecting points and pillars. The hills are covered with a considerable amount of loose material, worn rocks, &c. The valleys are also covered with a heavy superficial deposit.

From Bear creek to Echo Kanyon Station, 20 miles, most of the way is over the red grit beds. The railroad runs directly down the Echo valley from its source to its junction with the Weber valley. Its scenery is wonderful from its general ruggedness; the water is excellent; the grass is good and all the valleys are susceptible of cultivation. Timber, though scarce everywhere, is more abundant than in localities farther to the east.

Passing down Echo Kanyon from Hanging Rock Station to the mouth of Echo valley, bluffs of massive sandstone rise upon the right to a height of from 400 to 1000 feet, colored gray and yellow, yellowish purple and brick red, and containing some conglomerate.

A mile below Hanging Rock a drift into the bank 20 feet beneath a bed of conglomerate, discovered six inches of carbonaceous clay between two beds of ash colored, somewhat sandy, indurated clay, each about 6 feet thick. Below the coaly layer there are 2 inches of a material, which an analysis shows to be composed of Water 2.62, Volatile Matter 73.92, Sesquioxide 1.41, Lime 0.87, Magnesia trace, Sulphuric acid 0.37, Phosphoric acid a trace, Silica 59.14—99.80.

From the mouth of Echo up the valley the rocks seem to form a sort of gentle anticlinal for about 10 miles and then the inclination is reversed. The general dip however is 5° to 15°, nearly north-west; but for 6 miles below and 3 miles above Hanging rock it is increased to 25° and even to 35°.

This formation, which differs somewhat lithologically from any with which I am acquainted, must have an aggregate thickness of at least 3000 feet. The conglomerate portion must be at least 1500 feet in thickness. It includes beds of coal, and shows a few fossils, which are all either impressions of deciduous trees or marine shells.

Near Coalville, a little town in the valley of Weber river, 5 miles above the mouth of Echo creek, coal outcrops several times. At Spriggs' opening the dip is 20° or 30° east; and the coal bed about 15 feet thick; capped with gray sandstone, much of it charged with pebbles. I was informed that in other places this pebbly sandstone rests directly on the coal bed. A few hundred feet from Spriggs' opening, a shaft to strike the same bed has been sunk 79 feet deep, through 12 feet of gravel and sand, into black clay growing harder downward, and holding numerous specimens of a species of *Inoceramus*, *Ostrea*, and *Ammonites*, showing that the black clays are certainly of cretaceous age. If these beds do actually lie above the coal as the dip would indicate, then this formation of doubtful age, extending from Quaking Asp Summit to Salt lake, must be cretaceous, and some of the finest coal beds in the West are in rocks of that age.*

The Weber river flows directly west and the rocks incline in a sort of half circle between north and south. Several beds of massive sandstone cap the high hills, and between them are layers of clay with a reddish tinge. I was informed that there were in this section 6 or 7 beds of coal varying in thickness from 18 inches to 15 feet.

Passing down the Weber valley the dip would carry down the Coalville coal beds, in a distance of 5 miles, that is, at Echo City, to a depth of from 1200 to 1500 feet beneath the surface. So that the coal area that can ever be made available for economical purposes in this region must be very limited.

An interesting feature along the Weber river is its terraces. Near Echo City there is a rather narrow bottom near the river; then an abrupt ascent of 30 feet; then a level plain or bottom of 200 to 400 yards; then a gentle ascent to the rock bluffs. The summit of the first bluff at Echo is 500 feet high; it then slopes back to the plains beyond.

Passing down the Weber valley, about a mile below Echo Station, the beds begin to dip 25° N. E. The whole valley is filled with rounded

[* Confirming the published opinions of Dr. Le Conte and Dr. Newberry.—EDITOR.]

boulders, some of them 3 to 4 feet in diameter. The Weber river throughout the greater part of its course seems to plough through a monoclinal valley; but just before reaching the entrance of Lost creek it seems to pass along a local synclinal valley. A long ridge of conglomerate extends down from the direction of the Wasatch mountains, nearly north-east and south-west, inclining nearly north-east 5° to 10°. At this point, the Weber, instead of continuing in the synclinal valley, cuts through the ridge, isolating a portion about half a mile in length and forming a huge chasm, or gorge, which is called here the Devil's Gate. After passing through this ridge, the Weber receives Lost creek, and makes an abrupt bend to the southward; and here are exposed an immense thickness of the older rocks in a nearly vertical position. These rocks extend down the Weber river four miles or more, when the beds abruptly change from the nearly vertical position to a nearly horizontal one.

Commencing near the "Narrows," or the mouth of Lost creek, we have a considerable thickness of the jurassic limestones and marls, dipping 70° or 80° north-east, of a bluish ash color, very hard and brittle, cleaving into thin layers, and fracturing in every direction, so that the sides of the hills are covered to a great depth with its debris. Then comes a series of mud shales, with ripple marks, some layers of very white sandstone, and a thick bed of hard red sandstone, destined to take the highest rank among the building stone of Utah. It can be easily wrought into fine forms for culverts, fronts for buildings, caps and sills, &c. Then comes a vast thickness of gray, and dark gray, more or less cherty, limestones, which are probably carboniferous; and below these again a very hard silicious rock, oftentimes massive, which I referred to the Potsdam period, portions of which are filled with holes at right angles to the layers, very similar to much of the Potsdam east of the Mississippi pierced by *Scolithus linearis*. In this quartzose group there is a bed of shaly limestone, 6 to 10 feet thick. A few indistinct molluscs, were observed in the limestones and the mud shales.

The distance from the mouth of Lost creek to the end of the nearly vertical series of rocks is about three miles. So that we have here a thickness of strata not much less than two miles from the top of the Jurassic downwards so as probably to include the Silurian.

At the mouth of Lost creek, there is a remarkable example of non-conformity in hills of different ages. The reddish conglomerate rests directly upon the upturned edges of the vertical beds described above, and it is an important question what has become of all the intermediate beds, containing the coal, which are so conspicuous about 5 miles above Echo city.

Descending the Weber from the "Narrows" we find some of the most remarkable rugged scenery in the west. The walls are very noticeable, and are formed of two beds of limestone, projecting from the sides of the valley, at right angles, from between which 10 or 12 feet of loose material has been washed out. Near the tunnels the rocks on the left side of the Weber dip about 10°, nearly north, while on the other side the strata incline in the opposite direction 3° to 5°, as if the valley was anticlinal.

Then again the valley would appear to be monoclinal, the strata on the right side of the river inclining 20° south, and on the opposite side, though presenting a nearly vertical front, inclining south also. A little farther on down the valley, and on the right side of the river, come beds of red sandstone; below these again gray sandstone, with a reddish tinge, the red sandstone dipping east 12°; while on the opposite side of the river, the hills are open, rounded and grass covered.

The cherty crinoidal limestone extends to Morgan city and generally disappears. The red sandstones are seen among the foot hills.

At Morgan city, we come out of the principal cañon of the Weber, into a broad open bottom, filled with little villages and farm houses. The soil is of great fertility. The hills on either side are smoothed off and covered thickly with loose material and vegetation. The high vertical exposures all disappear. The Wasatch range seems to trend nearly north and south; even the foot hills of this range are so smoothed off and covered with drift and then with grass, that the underlying rocks are not to be seen. The industry shown by the Mormons in this valley is worthy of all praise. The little streams are made use of to irrigate the rich bottom lands, which produce abundantly, and the houses look neat and comfortable. Fruit cannot be raised to any extent in the Weber valley. The varieties of trees are confined mostly to the bitter-cotton-wood, although from Echo city down, we meet with a small dwarf, oak-box, elder, striped maple, and choke-cherry.

Just below the little village of Enterprise, I saw in the hills rocks composed of an aggregate of quartz pebbles, the whole mass looking like the Potsdam. Still farther down, we come to feldspathic rocks, indicating that the dip of the gneissic beds of the Wasatch range is westward. The Wasatch range is composed of gneiss so far as the rocks can be seen along the Weber. The rocks are beautifully banded everywhere. There are also coarse aggregations of quartz and feldspar with large masses of tourmaline; and all through the gneiss are seams of feldspar and quartz of various thicknesses.

The evidence is quite clear that from Morgan city to the entrance of the Wasatch Kanyon stretched a lake, the waters of which must have filled up the valley, rounded off the hills and covered the sides of the mountains with loose debris. Along the sides of the Kanyon of the Wasatch, 4½ miles long, are thick deposits of loose sand interspersed with water worn boulders in many places. These deposits have been cut through in making excavations by the railroad, and the lines of current deposition are curiously well marked. About half way through the kanyon, there is a sudden bend in the Weber river, by which a small portion of one of gneissic ridges is cut off. Opposite this ox-bow, a kanyon descends the mountain side, down which a vast quantity of loose material has been swept, filling the channel of the river with local drift, and probably driving the current through the gneissic ridges. The Weber river, if its channel were straightened, would run through this deposit of drift, which is about 30

feet thick; instead of which, it makes a bend and cuts its way through a massive gneissic ridge.

Extensive deposits of whitish, fine blue and rusty yellow sandstones, hard enough for building purposes, with flesh colored marls, probably of pliocene age, and resembling very closely in many respects the more recent tertiary beds along the Platte, occur in this valley. These recent beds dip east or south-east. We thus learn that some of the later movements in the elevation of these mountain ranges have been of comparatively modern date. Terraces continue to show themselves the entire length of the Weber river, and they are probably synchronous with those which surround the basin of Salt Lake valley.*

Fig. 5.

After emerging from the Wasatch Kanyon of the Weber valley, we pursued a southerly course along the base of the Wasatch range to Salt Lake city. For 20 miles or more, all the unchanged rocks have been worn away from the flanks of the mountains or completely concealed by debris. All over the gentle slopes at the foot of the mountains are strewn masses of rocks; all gneissic and evidently from the central parts of the mountains. Terraces distinctly surround this basin everywhere. There is one large one, with two or three smaller ones, on the sides of the mountains, and from the lowest one downwards, the surface slopes gently to the lake. I was informed that the lake had risen 9 feet vertically since 1868, and of course the water has aggressed upon the land to a great distance. I have heard no explanation of this phenomenon. All the lakes in the west are said to be rising more or less.

* This illustration from a sketch by Mr. F. W. Meek of the terraces along the Missouri river between Council Bluffs and Sioux City, will apply equally well to Helena or Salt Lake valley; and they are doubtless synchronous in age. In the sketch, the distant high hills are composed of yellow marl or "loess," the terraces the same, and the bottom of rich vegetable mould.

The carboniferous limestones begin to make their appearance along the flanks of the mountains about 10 miles north of Salt Lake city, and continue to a great or less extent all around the rim of the basin.

On the flanks of the mountains, east of the city, are the red beds (jurassic?); probably a careful study would reveal jurassic, cretaceous, and possibly even tertiary beds. President Young has long since offered a large reward to any one who would discover workable beds of coal within a reasonable distance of the city, and a thorough search has been made for them, but thus far without success. A bed of coaly clay only has been found near the city in the mountains. All the coal used in the valley is transported in wagons from Coalville, on the Weber. The best of red sandstone for building purposes is brought from red sandstone cañon, just east of the town. I am inclined to believe that it is carboniferous. The beautiful gray granite which is used in the construction of the Mormon temple is brought from Cottonwood valley in the Wasatch mountains. It is composed of white feldspar, qnartz and black mica.

The surface of Salt Lake valley has been rendered fruitful by the industry of the Mormons. Like the greater portion of the west, it was originally a vast sage plain. Now by irrigation all kinds of cereals and roots grow luxuriantly, and there are no better apples, peaches, plums, grapes, &c., raised in America. It may eventually become a vine growing region.

Following the stage road eastward, 16 miles from Salt Lake city to the Brewery at the mouth of Parley's Kanyon, we reach the foot of the mountain, over sand beds which are probably of post-pliocene age. Here a little stream cuts through the sand beds, exposing a vertical bluff 200 feet high, composed of some fine sand, horizontally stratified and overlaid with a great thickness of water worn pebble conglomerate. There are indications all along the flanks of the mountains, that nearly or quite all the formations already recognised as far west as this point are here represented. At the entrance of the kanyon, the carboniferous limestones dip north-east 70° to 80°; over them lie the purple and red sandstones and rusty yellow layers; and under them reddish shales. Beneath these shales an immense thickness of dark gray silicious rock stands nearly vertical. All this vast thickness of older rocks, in appearance semi-metamorphosed, are undoubtedly the counterparts of the series described in the Weber valley just below the entrance of Lost creek.

The road passes up a monoclinal valley between the ridges of silurian (?) rock, having a brittle fracture, and the monoclinal slopes are covered with debris. No gneissic rocks are noticeable along this road.

Before reaching the summits, in fact soon after we begin the ascent, we come to the conglomerates and sandstones which accompanied us down the Echo and Weber valleys. Near the summit all the hills are rounded by erosion and grassed over, and water-worn boulders are scattered about here and there, so that the underlying rocks are partially concealed. Just beyond the summit we arrive at a broad open exposure in the valley of the stream called Parley's Point, half a mile wide, and about 7000 feet

above sea level. Settlements are numerous all along the road; but while there is very good grazing, few of the cereals will grow.

All the rocks on the eastern slope incline at a greater or less angle apparently towards the east. Just as we enter Silver Creek valley, we come to numerous upthrusts of partially changed sandstones and conglomerates, the first indications that we get along our route of the neighborhood of igneous rocks. Some of the masses of rock which go to make up the conglomerate are of great size, very compact and of a steel gray color, and are enclosed in a gray siliceous paste; but whether large or small, all are angular. The formation looks much like that near South Boulder creek, near Denver.

Passing down the valley of Silver creek, we soon emerge into the valley of the Weber. We come to the hills enclosing the coal which dip down the valley at angles of from 20° to 50°, and of course the belt along which the coal beds are exposed is very narrow. Five or six beds as I have before said, varying in thickness from a few to 15 feet, are reported. I heard also that about 4 miles from Mr. Sprigg's opening, a bed of fossil oysters had been seen above the coal. That these coal strata are of marine or estuary character I have no doubt; but the limited time given me for their study prevented me from securing such positive evidence as is desirable; and as this formation occupies a vast area west of Fort Bridger, it seems all the more important to fix its geological position. That it is not older than the cretaceous we know by the occurrence of leaves of deciduous trees, and the black plastic clays of No. 2, holding quantities of fragments of fish-remains.

I will now recapitulate briefly the principal geological formations along the line of the Union Pacific Railroad from Omaha to Salt Lake city.

The Upper Coal Measure Limestones are seen at Omaha, near the water's edge, and quarried all along the Platte nearly to the Elk Horn river.

The Lower Cretaceous rusty sandstones of No. 1, overlap the Upper Carboniferous limestones about four miles above the mouth of the Platte, and extend to the mouth of the Loup Fork; but the yellow marl deposit or loess, conceals for the most part the underlying rocks. A fine yellowish sand, of the same age, or a little less recent, overlaps the cretaceous near Columbus.

The chalky limestones of No. 3, with the characteristic *Inoceramus problematicus*, here and there crop out, and some obscure exposures have been detected in the Pawnee Reservation, 15 or 20 miles up the Loup Fork.

This fine yellowish sand soon gives place to the Pliocene beds of the Platte, Loup Fork and Niobrara rivers, indurated marls, sands, or sandstones, which continue on as far as the margin of the Laramie range of mountains, 530 miles west of Omaha, that is, for nearly 430 miles along the line of the railroad. In the grand anticlinal of the Laramie range, which I have already described, they sometimes repose with a slight discordance on the older rocks; sometimes, as near the Laramie peak, they rest directly on the syenites, and entirely conceal, for a distance of 40 or

50 miles, all the unchanged rocks of older date; but a careful study of the eastern flank, from Red Butes to Long's Peak, will reveal all the formations that are known to exist in this part of the west, inclining from the sides of the granitic nucleus at various angles.

The railroad then for 40 miles passes over and cuts through a great variety of Syenites; some compact, beautiful building stones, almost equal to the Scotch lyenites, but the greater part ferruginous and easily disintegrating on exposure.*

Fig 6.

On the west side of the Laramie range, we pass across the upturned edges of the counterparts of the various formations seen on the eastern slope. From Laramie city to Salt Lake, formations of different ages continually appear and disappear. The Cretaceous formations occupy the country for 60 miles from Laramie city nearly to lake Como.

Genuine Jurassic beds, with characteristic fossils, are here exposed for a short distance, in an anticlinal valley, along which the railroad passes. *Belemnites densus* are in great numbers.

Cretaceous beds mostly No. 2, appear again west of Como.

Miocene coal beds overlay the cretaceous, just before reaching Carbon

* These syenites weather into most beautiful forms resembling gigantic ruins, so that they have sometimes deserved their common appellation, of broken down temples, castles, &c. The sketch, (Fig. 5,) shows well the peculiar features which these piles of rocks assume through atmospheric influences. It is engraved from a photograph of a scene on the Laramie range, taken by Mr. Carbutt, photographer, of Chicago, Illinois.

Station, 80 miles west of Laramie. At Carbon where they are exposed to view, impressions of fossil leaves occur in the greatest abundance. The species are few and nearly all of them identical with those described by Dr. Newbury, from the miocene tertiary beds of the Upper Missouri. Some strata consist almost entirely of leaves, in a fair state of preservation, as if they had not been subjected to a great deal of drifting prior to deposition. Indeed, the trees themselves must have grown near the spot, to shed their leaves in such great abundance, just as we find leaves accumulated now in muddy bottoms. Dr. Newbury has identified from this locality, *Populus Cuneata*, *Populus Nebrascensis*, *Platanus Haydeni* and an undescribed species of *Cornus*. The Wyoming Coal Company's shaft sunk at this station to reach the coal, has descended nearly 60 feet through a considerable thickness of bluish-black arenaceous clay, in rather thick layers, upon the surface of which are great quantities of *Populus* and *Platanus*. Very nearly the same species are described throughout a great thickness of these tertiary beds, and the evidence seems to be pretty clear that the vegetation was nearly uniform throughout the period of the deposition of the coal strata.

The Cretaceous beds are again exposed in a sort of anticlinal valley, about 10 miles east of the N. Platte crossing. But a few miles on either side of the railroad tertiary beds are seen.

At Rawling's Springs, all the formations from the syenites to the cretaceous, are thrown up over a restricted area; 2 miles farther west, the tertiary beds again overlay. At Separation, 26 miles west of Benton Station, a bed of excellent coal has been opened by the railroad company, in the rocks over which *Platanus Haydeni* and *Cornus acuminata*, (N,) with other undetermined species of plants occur. This forms the eastern rim of a basin which extends about 110 miles to the westward.

Soon after leaving Separation, the strata becomes nearly horizontal, and are of fresh water instead of estuary origin. Beyond Bitter Creek Station, estuary beds reappear dipping east. At Washakie, Red Desert and Table Rock occur thick beds made up of an aggregate of fresh water shells, of the genera *Unio*, *Paludina*, *Limnea*, *Melania*, &c., At Black Butes and Point of Rocks, a great abundance of impressions of deciduous leaves are found. At Black Bute Station, about 850 miles west of Omaha, I found in the coal strata *Sabal Campbelli*, N, *Rhamnus elegans*, *Cornus acuminata*, *Quercus aceroides*, *Tilia antiqua*, with some undescribed species.

At Point of Rocks, an important coal station, about 14 miles farther west, I found *Platanus Haydeni*, *P. Nebrascensis*, *Cornus acuminata*, and *Magnolia tenerafolia*. In the vicinity of Elk mountain, along the overland stage road, in beds which I regarded as belonging to the older tertiary, and holding a position near the junction of the tertiary and cretaceous, and nearly or quite on a parallel with the lower tertiary beds near Denver, Colorado, I found *Platinus Haydeni*, *Quercus aceroides*, *Magnolia tenerafolia*, with fragments of *Cornus* and *Rhamnus*.

Near Green River the eastern rim of what appears to be another tertiary basin commences, the beds having a gentle dip to the westward. Between

Green River crossing and Bryan Station, fine specimens of fossil fishes occur in rocks which resemble the Solenhofen slates. West of Bryan, fresh water shells of the genera *Corbicula*, *Limnea*, *Physa*, *Paludina*, *Melania*, and *Unio* occur in the greatest quantities. This basin extends to Quaking Asp ridge, 22 miles west of Fort Bridger.

We then come to a series of variegated beds, whose dominant color is red or reddish, of estuary or marine origin, with coal beds from 6 to 15 feet thick. These extend far westward to the Wasatch mountains, possibly farther. The evidence inclines one to regard them of cretaceous age, but they may be older tertiary.

In Weber valley there is an immense thickness of the older sedimentary rocks from the jurassic inclusive to the silurian inclusive, the thickness of which I estimated at from 5,000 to 10,000 feet.

The Wasatch range is composed of metamorphic rocks, mostly gneisic, which are well shown in the valley of Weber river for the distance of 4 miles.

The Union Pacific Railroad from Omaha to Salt Lake valley, a distance of nearly 1200 miles, really pass through metamorphic rocks but twice; first in crossing the Laramie range, a distance of 20 or 30 miles, and in the Weber valley through the Wasatch range, 4 miles. At Rawling's Springs, the syenites are seen on the north side of the road for a little distance, but not immediately along it.

It will thus be seen that over the vast region known as the Rocky Mountain district proper, the area that can be colored on a geological map as occupied by igneous or metamorphic rocks is comparatively small, while the more modern formations as tertiary and cretaceous, are met with everywhere even up to the summits of the loftiest ranges and sometimes covering them.

NOTE. The illustration, Plate 1, Fig. 2, Pulpit Rock, shows the high nearly vertical bluffs of conglomerate, at the entrance of Echo creek into the Weber river, Utah Territory. I am inclined to regard these rocks as older tertiary, from the fact that they lie along the coal beds of this region, but they may be cretaceous.

Twin Peaks, No. 1, Plate 1, form a part of a mountain range, enclosing Salt Lake valley. The terrace system is well shown, as described in the preceding paper.

ON THE GEOLOGICAL AGE AND EQUIVALENTS OF THE MARSHALL GROUP.

By Prof. A. Winchell.

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I. Existence of Controversy.

Every person conversant with the history of American geological science is aware of the controversy which has long existed in reference to the age and equivalents of the strata lying between the Corniferous limestones and the limestones of the Lower Carboniferous system. Geologists of the highest ability—both American and European—have participated in the discussions; and western geologists, almost without exception, have been constrained to commit themselves, for specific reasons, to definite, though often diverse, views in reference to the geology of the zone in question. As additional facts have been successively brought to light, some important progress has been made in the settlement of controverted points; and the great body of western geologists seem to have united with considerable unanimity in a judgment upon the main issues. Very persistent oppo-

sition is manifested, however, in certain quarters, to the verdict which is already shadowed forth; and there are probably few whose convictions have been satisfactorily and finally settled by a comprehensive comparison of the facts which have been collected. I think, therefore, it may be useful, in the present state of opinion, to bring forward a review of the data upon which the controversy has proceeded, and to furnish the grounds of the convictions which for some years past have been strengthening in my own mind. In doing this, I hope I shall be actuated by a spirit of candor, and sentiments of profound respect for the distinguished names arrayed against my position. I seek only the truthful determination of the question; and I would not raise my voice in a discussion where so many worthier ones have been heard, did I not recall to mind that the merest child, or the humblest peasant may stumble upon phenomena which the philosopher had long sought in vain, and which may serve as the solvent of chronic and distressing doubts.

II. History or Discovery and Opinion.

So far as I have observed, the first distinct allusion by any geological writer to the zone of rocks under consideration, is embraced in an elaborate description of the topography and geology of the "bituminous coal deposits of the valley of the Ohio, and of the accompanying rock strata" by that distinguished pioneer of western geology, Dr. S. P. Hildreth.[1]

In the section which he has given of the "Ferruginous deposits,"[2] it would appear that the lower beds, 500 feet in thickness, extend into the series afterwards designated the "Waverly series" by the Ohio geologists. Dr. Hildreth styles them the "Great Lias Rock," and afterwards an "Argillaceous sandstone rock, very fine grained," &c. Dr. S. G. Morton appends to this paper descriptions and figures (mostly too imperfect for identification) of several species of included fossils.

In 1838, Mr. C. Briggs,[3] assistant upon the geological survey of Ohio, bestowed the name "Waverly Sandstone Series" upon the lower portion of the succession of shales, sandstones, and shaly sandstones, interposed between the so-called Black Slate and the great Carboniferous Conglomerate. The series took its name from the village of Waverly in the southern part of the State in Pike county, since some of the most beautiful building stones afforded by the series had been quarried at that place. The Ohio geologists, however, in other and subsequent publications, generally referred to this assemblage of strata under the designation of "Fine Grained Sandstone Series."[4] The lower limits of the series, as defined, were distinctly marked by the horizon of the Black Shale; but the upper limits were not stated with precision. It does not appear however that the series was originally supposed to reach upwards to the Conglomerate;[5]

[1] Amer. Jour. Science and Arts, vol. 29, p. 1, and Plates 1 to xxxvi

[2] Ib. p. 133; also 136. [3] First Ann. Rep., Ohio, p. 79.

[4] See for instance "Report of Special Committee to report on the best method of obtaining a complete geological survey," 1836, p. 13, where the expression seems to have been first employed; Whittlesey, Second Ann. Report, 1838, p. 56; J. W. Foster, Ib. p. 76; Briggs, Ib. pp. 122, 130.

[5] Whittlesey, 2d Ann. Rep., p. 56.

though the Ohio geologists appear eventually to have given the term "Fine Grained Sandstone Series" that extension of meaning; and Col. Whittlesey, Prof. Hall, Dr. Newberry and others, have since treated the term "Waverly series" as synonymous. The Ohio geologists abstained, on principle, from expressing any opinion on the subject of the American or foreign equivalents of these rocks.

During the same year, Mr. J. W. Foster[6] made a report in which he described the Fine Grained Sandstone of Licking and Franklin counties, as a continuation of the Waverly series of Briggs, and expresses the opinion that it is "a member of the mountain limestone formation." I direct particular attention to this early judgment. It must be noted, however, that the older Cliff Limestone was also at that time regarded as belonging to the mountain limestone series. Both Foster and Briggs speak of the paucity of organic remains in the lower portion of the series, and their abundance in the upper portion.

The public geological survey of Michigan was inaugurated at about the same time as that of Ohio. The earliest mention of sandstones in that State, occupying a position in the zone under consideration, is found in Dr. Houghton's report for 1838.[7] Under the head of the "Upper Sandstone of the Peninsula," he notices those rocks which I have designated[8] the "Woodville Sandstone" above the coal; the "Parma Sandstone" beneath it, and those portions of the "Marshall group" which outcrop in the southern counties. The outcrop of the last named sandstones in the vicinity of Pt aux Barques, east of Saginaw bay, is treated by Dr. Houghton in connection with the Lake Superior Sandstone under the head of "Lower Sandstone or Graywacke group" (p. 9).

In the report of the following year, the Marshall sandstones are again stated by Dr. Houghton to belong to "the great carboniferous group of rocks."[9]

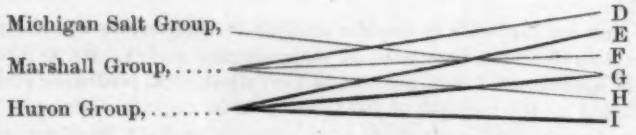
The first attempt at a systematic account of these strata was made in 1840 by Bela Hubbard,[10] assistant on the geological survey. Mr. Hubbard correctly apprehended their position as beneath the coal producing strata, and alluded to the richness of the lower beds in organic remains. *The deeper and more argillaceous strata were never, in southern Michigan, associated as in Ohio, with the newer and more arenaceous beds.* The entire series of argillaceous strata, including the black shale of the state, which is very inconspicuous in the southern counties, were described by Hubbard as the "Kidney Iron Formation." This was regarded as the bottom of the Carboniferous system. The northern outcrop of these groups were reported upon in 1841.[11] In his attempt to assign them to their proper stratigraphical position, Mr. Hubbard fell into singular errors, and introduced into the most elaborate account of the lower peninsula which was destined to be published for twenty years, a confusion of facts which rendered the geology of Michigan an enigma to every one who attempted to

[6] Second Ann. Rep. Geol., Ohio, p. 103.
[7] First Ann. Rep. Geol. Mich., p. 3.
[8] First Bienn. Rep. Mich., 1861.
[9] Mich. Geol. Rep., 1839, p. 28.
[10] Mich. Geol. Rep., 1840, p. 87.
[11] Mich. Geol. Rep., 1841, p. 114.

parallelize the rocks with those of surrounding States.[12] The following is Mr. Hubbard's tabular statement of the succession of groups embraced in the lower peninsula,

A. Erratic Block group or Diluviums,
B. Tertiary Clays,
C. Coal measures,
D. Sub-carboniferous Sandstones,
E. Clay and Kidney Iron formation,
F. Sandstones of Pt aux Barques,
G. Argillaceous slates and flags of Lake Huron,
H. Soft, light-colored Sandstones,
I. Black, aluminous slate,
K. Lime rocks of Lake Erie.[13]

In this table, as we now know, the groups marked D, F, and H, are but different outcrops of the Marshall group; and those marked E, G, and I, but different outcrops of the Kidney Iron or Huron group. Following Dr. Houghton in the report of 1838, Mr. Hubbard regarded the Pt aux Barques sandstones and conglomerates as occupying a position beneath the Kidney Iron formation of the southern portion of the state, and consequently failed to identify the underlying shales. In the next place, Mr. Hubbard identified with the Pt aux Barques shales, the shales of the "Michigan Salt group," struck in the salt wells at Grand Rapids, although these latter actually occupy a position above the Marshall sandstones. When, therefore, these sandstones and the underlying Huron shales were struck in the boring of the salt wells, they were supposed to constitute the third couplet of similar strata, and are set down as groups H and I, in the above table.[14] This confusion is illustrated by the following diagram:



The Pt aux Barques sandstone were rightly recognized by Hubbard as the equivalent of the characteristic portion of the Waverly sandstone series in Ohio; and it is singular that they were not observed to be equally identifiable with the sandstones of Hillsdale county in the southern part of the state. The upper conglomeratic portion of the Pt aux Barques sandstones was erroneously synchronized with the Carboniferous conglomerate, which though reposing on the Waverly of Ohio, is separated from the equivalent Marshall in Michigan, by the Carboniferous limestone and the Michigan Salt group. The Black Shale was also recognized as

[12] In his attempt, in 1843, to parallelize the strata of Michigan with those of other states, Prof. Hall assigned the Pt aux Barques series to the zone of the Waverly Series and the Portage and Chemung; but he seems not to have known how to dispose of the rocks denominated by Houghton and Hubbard the "Upper Sandstone of the Peninsula." Rep. Geol., 4th Dist. N. J., p. 519.

[13] See also Report, p. 136.

[14] Report, p. 133.

agreeing "in general character *and position*" with "the Black Shale stratum of Ohio and Indiana." [15]

In 1841, when Professor Hall was closing up his labors upon the geology of Western New York, he undertook an extended tour through the western states for the purpose of ascertaining to what extent the formations recognized in New York could be traced in other regions. The general results of this tour were announced in 1842.[16] At this time, he was led to regard the Waverly series (embracing everything between the Black Shale and the Conglomerate), as a prolongation of the Chemung and Portage groups of New York. The thick bedded sandstones at Newburg and Waverly were identified with the Portage sandstones, while the shaly sandstones and flags near Cleveland were regarded as representing the Gardeau shales and flagstones. From Newburg to Cuyahoga Falls, and also at Akron, he identified the shales and sandstones of the Chemung group.

Passing down the Ohio into Indiana, Prof. Hall again identified strata corresponding to the Portage, and doubtfully to the Chemung; while above these, and beneath the carboniferous limestone, was a series of arenaceous strata becoming interstratified above with beds of mountain limestone, and, on the whole, exhibiting affinities with the Carboniferous system. Nevertheless he inclined to regard them as "sub-carboniferous" (used in the sense of *subter-carboniferous*,) remarking that "a limit should be fixed between what is to be strictly referred to the Carboniferous period, and older deposits." [17] The Black Shale of Ohio and Indiana was regarded by Professor Hall as the equivalent of the Marcellus Shale of New York "being the only representation of that rock, the Hamilton group and the Genesee slate" (Ib. 280).

During the same year, Mr. Conrad [18] read a paper before the Academy of Natural Sciences of Philadelphia, in which he embraced brief descriptions of three fossils from the Marshall sandstone of Moscow, Michigan, which he referred to the Carboniferous system. Mr. Vanuxem's Report on the Geology of the Third District of New York, also appeared this year.

In 1847 the distinguished European geologist, de Verneuil, gave the world the results of an extended and critical investigation of the parallel-

[15] It is interesting to note this early identification of the now styled Marshall sandstones with the characteristic portion of the Waverly sandstone series; and the Black Shale of Michigan with the Black Shale of Ohio and Indiana; as these opinions were expressed by Hubbard anterior to the first elaborate attempts by Hall and de Verneuil to trace the parallelism of formation in the different states. Dr. Houghton had, indeed, previously recognized the correspondence of the "Black Shale" with certain formations in western New York, as described in the annual reports of that State; though there is room to doubt whether he made the identification preferably with the Marcellus or the Genesee Shale. Under the great natural difficulties attending the exploration of the "wilderness of Michigan," then just emerging from a territorial condition, and the equally great embarrassments resulting from the undisturbed condition of the strata, it is indeed remarkable that the early geologists of the state succeeded in establishing so many conclusions which have stood the test of nearly a third of a century.

[16] Amer. Jour. Sci. and Arts, xlii p. 51; Jour. Bost. Soc. Nat. Hist. v. p. 1, and more fully in Trans. Assoc. Amer. Geol., p. 267. See also Geol. Rep., Fourth Dist. N. Y., p. 229.

[17] Trans. Assoc. Am. Geol., p. 281.

[18] Jour. Acad. N. S., Phil., vol. viii, p. 249 and 269.

ism existing between American and European paleozoic formations.[19] This paper was translated and somewhat condensed by Professor Hall for publication in America.[20]

Professor Hall's translation is accompanied by criticisms and additions.[21] One of the results of de Verneuil's studies was to lower the base of the Devonian system from the bottom of the Portage group where it had been placed by Conrad, to the bottom of the Oriskany sandstone, and to fix the summit above the Catskill group. He recognized the prolongation of the Portage and Chemung groups into Ohio, but did not detect them in Indiana, Kentucky, and Tennessee; though Prof. Hall in his notes upon the paper, was inclined to recognize them in Indiana above his and Owen's "sub-carboniferous." The upper, or fossiliferous portion of the Waverly series was regarded by de Verneuil as falling within the limits of the carboniferous system. The Black Slate of the West was identified with the Genesee Shale of New York. These conclusions are fortified by extended paleontological comparisons.

Professor Hall in his commentary upon this elaborate paper, seems to oscillate between two opinions. He insists at one time upon the Silurian relationships of the Hamilton, Portage and Chemung, and the broad lithological and paleontological gap intervening between the Chemung and the Catskill,[22] intimating that there is the place to draw the systemic lines; while at another time he asserts that the Chemung is more intimately "related to the Carboniferous sandstones of the West than the Hamilton group of New York"[23]—that "there is no well defined line of separation between the Chemung rocks of New York, and the sandstones of Ohio and Indiana, which contain carboniferous fossils"—and that "the error of American geologists who have attempted to compare our formations with those of Europe, has been, in this instance, that of regarding the great Carboniferous limestone as forming the basis of that system, including all the strata below it in Devonian and Silurian."[24]

In 1848 Mr. Murray, of the geological survey of Canada, made an examination of black bituminous shales on the south-east shore of Lake Huron at Kettle Pt., and described them[25] under the head of "Hamilton group," remarking that they contained *Lingula*, but "neither of the two species represented by Mr. Hall as belonging to the Genesee slate." Mr. Murray adds that "no trace of the sandstones [of the Portage and Chemung groups] . . . has yet been met with in western Canada."

[19] "Sur le parallélisme des dépots paléozoïques de l'Amerique Septentrionale avec ceux de l'Europe; suivie d' un tableau des éspèces fossiles communes aux deux continents, avec l' indication des étages où elles se rencontrent, et terminée par un examen critique de chaque de ces éspèces." Bulletin de la Soc. Geol. de France, 2me Ser. Tome, IV, p. 646.

[20] Am. Jour. Sci. and Arts, [2] vol. v. pp. 176 and 359 and vol. vii. pp. 45 and 218.

[21] See further critical remarks by Sharpe, "On the Paleozoic Rocks of N. A.," in Quar. Jour. Geol. Soc. Lond., Aug. 1848, and a paper by Mr. Elie de Beaumont, entitled "Note sur les systémes de Montagnes les plus anciens de l' Europe."

[22] Amer. Jour. Sci., [2] v. 367, Note; vii, 46, Note 3 and p. 231. He had previously pointed out the break below the Catskill. Pal. N. Y., vol. 1, introd. p. xvi.

[23] Amer. Jour. Sci., [2] vii, p. 46, Note (a,)

[24] Amer. Jour. Sci., [2] vii, 45, Note.

[25] Report of Progress, 1848-9, p. 24.

In 1850 Professor Hall resumed the discussion of the parallelism of eastern and western formations, and the parallelism of the whole with the standard systems of Europe.[26]

In this celebrated discussion, Professor Hall states that "the shales and sandstones of the Catskill mountains, . . . have no representatives at the West. Succeeding the Black Shale, however, there is a group of shales and sandstones which, from the fossils they contain, are regarded as belonging to the Carboniferous period."[27] And again, "the green shales and sandstones of Ohio and Indiana, which succeed this Black Shale, have been recognized as carboniferous by their fossils, though there is still some doubt whether the lower part may not represent the Chemung group of New York."[28] He still insists on the carboniferous aspect of the rocks from the Marcellus to the Catskill, and cites, after de Verneuil, the *Goniatites rotatorius* and *Goniatites princeps* as proving the carboniferous age of the "Rockford bed" which he regards as embraced in the Marcellus shale.[29]

About the same date, Mr. Murray[30] reported new observations on the Black Shales of Canada West, in the region more recently famous for its production of petroleum. These he still regarded as embraced in the Hamilton Group, and probably continuous with those previously examined at Kettle Point. He remarks that the "bituminous springs [of Enniskillen] probably owe their origin" to this formation.

In 1851, Mr. Christy[31] read a paper before the American Association at its Cincinnati meeting, in which he announced that the Rockford Goniatite limestone is centrally located in the Black Slate of Indiana, and according to Verneuil embraces the carboniferous fossils *Goniatites rotatorius* and *G. princeps*, and *Cyclolobus*. Mr. Christy specifies several localities at which the limestone and the slate may be seen in juxtaposition, and accounts for Dr. D. D. Owen's error in pronouncing the limestone a portion of the Cliff limestone. Mr. Christy states that the Goniatite limestone has about 28 feet of black shale below it, and about 30 feet of black shale above it. The latter is succeeded by "about 350 to 400 feet of soft shale with an occasional stratum of limestone and some beds of sandstone, including fossils."[32]

At the same meeting Col. Whittlesey[33] read a paper "On the equivalency of the rocks of north-eastern Ohio, and the Portage, Chemung, and Hamilton rocks of New York." Col. Whittlesey's extended and accurate observations in the state, enabled him to furnish valuable sections of the Ohio strata, to which I shall have occasion again to refer. Following Professor Hall in his paper published in 1842, he places the Ohio rocks, from the Cliff limestone to the Conglomerate, in the zone of the New York Upper Devonian.

In 1852 Dr. D. D. Owen[34] published a geological map of the North-west,

[26] Foster and Whitney's Rep. Min. Land District, L. Sup., vol. II., chap. xviii, p. 285.
[27] Ib. p. 292.
[28] Ib. p. 307.
[29] Ib. p. 309.
[30] Rep. Progress Geol. Sur. Can., 1850-51, p. 29.
[31] Proc. Amer. Assoc., vol. v., p. 76.
[32] Ib. p. 80.
[33] Ib. p. 207.
[34] Geol. Rep. Wis. Iowa, and Minn.

in which he colored as Carboniferous, all those regions in Missouri and Iowa underlaid by rocks intervening between the Carboniferous limestone and the Black Slate. Dr. Owen embraced in the Mountain limestone series, the yellow sandstone at the base of the exposure at Burlington, Iowa, and from the associated oölitic bed he describes and recognizes *Producta Cora, Spirifera striata* and *Cryroceras Burlingtonense* (Ib. p. 95).

Professor Swallow[35] in his Missouri Report, published in 1855, recognizes the Chemung group, and establishes three divisions called respectively, in descending order, the "Chouteau limestone," the "Vermicular sandstone and shales," and the "Lithographic limestone." Professor Swallow in referring to differences of opinion about the age of these rocks, says: "Many of our fossils are either identical with, or very similar to those of the Chemung group of New York. Among these are a species of those remarkable forms of the New York reports called *Fucoides caudagalli?* and *Filicites gracilis;* also *Avicula subduplicata* and *Nucula bellatula.* Mr. F. B. Meek[36] in his appendix, enumerates 55 species of fossils from these rocks, of which 19 are described by Dr. B. F. Shumard as new species; 13 are identified with European carboniferous species, while one only, *Avicula duplicata* (Hall,) is identified with species from the Chemung of New York, and two—*Spirifera mucronata?* and *Nucula bellatula,* are identified with Hamilton species. Such determinations would seem to afford but slender support to Professor Swallow's decision, to range these rocks on the horizon of the Chemung.

During the same year Mr. Marcou[37] reproduced in Europe the geological chart of the United States, which he had first published in America[38] in 1853. In this chart he colors as underlaid by the Mountain Limestone, the entire area in Michigan which we now know to be occupied by the Marshall and Huron groups. The area of the Waverly series is colored as Devonian. This chart was again reproduced in 1858[39] with alterations, at which time, Mr. Marcou seems to have regarded the area of the Marshall group in Michigan as also of Devonian age.

Norwood and Pratten[40] in 1855, in describing *Chonetes Fischeri* from the yellow sandstones at Burlington, Iowa, refer them to the "base of the Mountain Limestone."

The "Knobstone" formation of Kentucky was ranged by D. D. Owen[41] in 1856, as "sub-carboniferous"; while the "Black Singula Shale," as he styles it, was regarded as Devonian.

Professor Safford[42] in the same year advanced the opinion that the Black Shale of Tennessee ought to be regarded as Carboniferous.

In Mr. Murray's[43] Canadian report for the year 1855, he decides to transfer the Black Shale of Canada West to the "Portage and Chemung

[35] Rep. Geol. Surv. Mo. I., p. 101.
[36] Ib. II, p. 218.
[37] "Geol. Karte d. Verein· Staaten," in Peterm. Mittheilungen, p. 149.
[38] Geol. Map of U. S., with explanatory text.
[39] Geology of North America, with Maps and Plates, Zurich.
[40] Jour. Acad. Nat. Sci., [2] vol. III, p. 25.
[41] Geol. Rep. Ky., vol. I. p. 89.
[42] Geol. Reconnoissance Tenn., p. 158.
[43] Rep. Geol. Surv. Can., 1853-6, p. 129.

group;" assigning as his motive the fact that "Professor Hall, on seeing the section at Kettle Pt., expressed it as his opinion that the rocks were the lowest measures of the Portage and Chemung group," and the fact that "a nearly complete section of the Hamilton group" had been discovered on "some of the tributaries of the River Sable (south)."

The ferruginous shales of the Marshall group of Michigan were again pronounced Carboniferous in 1858, by Dr. R. P. Stevens,[44] who described from Battle Creek three species of *Leda* and one species each of *Nucula* and *Chonetes*. These are spoken of as occurring in "association with an *Orthoceras*, *Nautilus*, and *Bellerophon Urei*, which is evidently carboniferous."

In the same year, Professor Hall [45] published his Report on the geology of Eastern Iowa, in which he embraced the first separate account which I have observed of the yellow sandstones which outcrop on the banks of the Mississippi at Burlington and other localities. He speaks confidently of their equivalency to the Chemung rocks of New York, and points out a bed of green shale at the base, which he thinks might represent the Portage group. He does not fail to recognize, however, the imperceptible graduation of these sandstones into the overlying Burlington limestone, and expresses the opinion that the Chemung group of Missouri, as organized by Professor Swallow, "will probably be found to include a portion of the Hamilton group."[46] Professor Hall describes eleven species of fossils from these strata, but makes no identifications with fossils from the typical Chemung of New York. Mr. C. A. White's "sections" of the rocks at Burlington, in the appendix to this report, possess very great interest, as embodying the results of exact observations.

In September, 1860, Messrs. Meek and Worthen[47] published descriptions of five new species of fossils from the Rockford limestone. In the same month, Mr. C. A. White[48] published "Observations on the Geology and Paleontology of Burlington, Iowa, and its vicinity;" embracing descriptions of seven new species from the yellow sandstones, and elaborate discussions establishing the intimate relations existing between the yellow sandstones and the overlying Burlington limestone.

During 1859-60-1, a geological survey of the lower peninsula of Michigan was in progress under my direction. The first public announcement of the determinations made upon this survey was in the form of a lecture delivered at the University by myself to an audience consisting mainly of a delegation from the Chicago Academy of Sciences, who were then on an excursion to the University of Michigan. This lecture was reported in full and published in the Chicago Tribune in December, 1860. A summary of the results of the survey was also published in the Detroit Tribune, December 11th, 1860, and briefly in the Detroit Advertiser of January 26, 1861. Advance sheets of my official report were sent off August 18th, 1861, and noticed in the American Journal of Science and Arts in September, 1861.

[44] Amer. Jour. Sci. [2] xxv., 262.
[45] Geology of Iowa, 1, p. 88.
[46] Ib. p. 91.
[47] Proc. Acad. Nat. Sci. Phil., September, 1860, p. 447.
[48] Jour. Boston Soc. Nat. Hist., vol. vii, p. 209.

In the several documents to which I have just referred, I stated distinctly that I regarded the Marshall sandstones of Michigan as the equivalents of the Fine grained sandstone series of Ohio, and the Black Shale of Michigan as equivalent to the Black Shale of Ohio and Indiana. I also stated as a matter of stratigraphical demonstration, that these black shales are seen in Thunder bay of Lake Huron and in Grand Traverse bay of Lake Michigan to rest *above* the well characterized Hamilton limestones. I had at first considered these black shales as the equivalent of the Genesee Shale of New York,[49] but in deference to the judgment of Professor Hall, personally expressed, I united them with my overlying Hudson group, which was organized to receive a series of bluish and greenish argillaceous strata beneath the Marshall sandstones, and supposed by me to correspond to the Portage group of New York.[50] I was not aware at that time, that Mr. Murray had had an almost identical experience,[51] as I have already stated.

In 1860, Professor Swallow[52] published descriptions of 19 species of fossils from the Chouteau and Lithographic limestones of Missouri; and in the same year, Mr. Lyon[53] published a section of the rocks of Kentucky, in which he ranges the "Knobstone formation" under "sub-carboniferous," and inclines to place the Black Slate in the same position.

Early in 1861, Professor Hall[54] published "Notes and Observations upon the Fossils of the Goniatite Limestone in the Marcellus Shale of the Hamilton group in the eastern and central parts of the State of New York, and those of the Goniatite beds of Rockford, Indiana, with some analagous forms from the Hamilton group proper." In this paper Professor Hall returns with strong assurance to his original opinion enunciated in 1842, that the Black Shale of the West is the equivalent of the Marcellus of New York, and that the ferruginous sandstones of Ohio and Indiana, are the equivalents of the Portage and Chemung. He describes as new 18 species from the Rockford beds including those recognized as *Goniatites rotatorius*,[55] and *Goniatites princeps* by Verneuil, and two species previously described by Meek and Worthen. He, however, fails to identify a single species from the Rockford limestone with any species occurring in the Marcellus Shale or other Devonian rocks of New York.

The same number of Silliman's Journal which contained the announcement of my official report, contained also a paper by Messrs. Meek and Worthen[56] on the "Age of the Goniatite Limestone at Rockford, Indiana, and its relations to the Black Slate of the Western States, and to some of the succeeding rocks above the latter." These authors deny that any portion of the Black Slate is found above the Goniatite limestone, as had been asserted by Christy, and announced that it lies entirely below. The limestone they identify with the Chouteau limestone of Missouri, founding the opinion on an identification of at least six out of 23 or 24 Rockford species, and a close resemblance amongst most of the others. They argue

[49] Mich. Geol. Rep., 1861, p. 78.
[50] Ib. pp. 79 and 139.
[51] In alluding to this fact in my report, I inadvertently attributed this experience to Mr. Billings; Report, p. 79.
[52] Trans. St. Louis Acad. Sci., 1, 635.
[53] Trans. St. Louis Acad. Sci., 1, 620.
[54] xiii. Report New York Regents App., p. 95.
[55] This is described as G. Ixion, in a note, p. 125.
[56] Amer. Jour. Sci., [2] xxxiii., 167.

with a degree of paleontological acuteness which cannot be gainsayed, that both the Rockford beds, and the three members of the Chemung group of Missouri as interpreted by Professor Swallow, present characteristics which forbid their introduction into the Devonian system. They affirm the judgment of de Verneuil, that the Black Slate of the West is the equivalent of the Genesee Shale of New York. In an appended note they propose to adopt the name Kinderhook group for the rocks in Illinois lying between the Black Shale and the Mountain Limestone.

Some time in 1862, Professor Hall[57] published a "supplementary note" to his paper on the Rockford limestone, in which he states that having identified the Rockford *Goniatites Hyas* among fossils from the Waverly sandstone of Licking county, Ohio,[58] he is led to "conclude that the position assigned to the Goniatite beds of Rockford may be erroneous, and that the true position is higher in the series, or more nearly in a parallel with the Chemung group."

During the year 1862 large additions were made to our exact knowledge of the species of fossils embraced in the series of rocks immediately underlying the Mountain Limestone. In February, Messrs. White and Whitfield[59] published a paper entitled "Observations upon the rocks of the Mississippi valley, which have been referred to the Chemung group of New York, together with descriptions of new species of fossils from the same horizon at Burlington, Iowa." This paper embraces descriptions of 31 new species. The authors in their introductory remarks, synchronize the yellow sandstones of Burlington, with the Chemung of New York, though admitting the strong paleontological contrast, and their striking affinity with the Burlington limestone and higher carboniferous rocks. This opinion is founded upon the identification of several Iowa and Missouri fossils with species from the Waverly series of Ohio, which is assumed to be in physical continuity with the Chemung of Western New York, as originally alleged by Professor Hall.

In April, Mr. White[60] published further descriptions of new species from the same horizon at Burlington, Iowa; Hamburg, Illinois; and Hannibal and Clarkesville, Mo.; and in the same month Professor Swallow[61] published descriptions of two new species from the Chouteau limestone of Missouri.

In May I published[62] a paper "On the rocks lying between the Carboniferous Limestone of the Lower Peninsula of Michigan, and the limestones of the Hamilton Group, with descriptions of some Cephalopods, supposed to be new to science." Of the species enumerated, 24 were from the Marshall group, and one from the Huron. In this paper the Black Shale

[57] Fifteenth Report New York Regents, App., p. 81.

[58] Having myself examined the fossils, I do not consider it identified with G. Ixion, Meek and Worthen (—G. Hyas, Hall.) but with G. Marshallensis, Winchell, which differs from G. Lyoni by constant technical characters, having an additional accessory lobe and saddle, and having the dorsal lobe broader and relatively longer. A transverse section of G. Lyoni, is broadest near the umbilicus, while a section of G. Marshallensis is regularly oval. Professor Hall's inference, however, remains unchallenged.

[59] Proc. Boston Soc. Nat. Hist. vol. viii, p. 289.

[60] Proc. Boston Soc. Nat. Hist., vol. ix, p. 8.

[61] Trans. St. Louis Acad. Sci., vol. 2, p. 81.

[62] Amer Jour Sci, [2,] xxxiii., 352.

of Michigan and Canada West, were again identified and ranged within the limits of the Huron group, next above the Hamilton.

In September[63] I continued the enumeration of Michigan species from the Marshall and Huron groups, giving 63 from the former, and 17 from the latter. Of the Marshall species, 5 were identified with fossils previously described from Rockford. Of the Huron species, 6 were identified more or less doubtfully with species from the Hamilton group of New York.

In November, Col. Jewett[64] and Professor Hall[65] both made publication of the results of late observations upon the rocks in Eastern New York, which had been embraced within the limits of the Catskill group upon the geological map of the state. Col. Jewett declared the opinion as the result of his examinations, that the Catskill group did not exist within the limits of the state; while Professor Hall admitted that the upper limit of the Chemung rocks must be carried in the Catskill mountains, "to an elevation of at least 2,000 feet above tide-water." He stated that it now becomes necessary to restrict the term *Catskill group* to the beds above [the Chemung of Delaware county, hitherto regarded as Catskill,] or to those formerly known as X and XI of the Pennsylvania Survey." He closes by remarking that "in tracing the Chemung group westward, there are many indications that it may require to be restricted in its designation," and that "the Waverly sandstone group of the Ohio reports, at one time regarded by [himself] as entirely equivalent to the Portage and Chemung groups, may, in its upper members, constitute a distinct group, though we do not yet know any line of demarkation between them."

In 1862, Professor R. Owen[66] in his Report on the geology of Indiana, ranges the shales and sandstones underneath the Mountain Limestone in a group designated after D. D. Owen, "sub-carboniferous," regarding them as at the base of the Carboniferous system, and the equivalent of at least some portion of the Waverly series of Ohio. The Black Slate he identifies with the Genesee Shale.

In January, 1863,[67] after having read Col. Jewett's announcement of the unreal character of the Catskill group, and Professor Hall's admission that this group must, at least, be very materially reduced in thickness, I gave utterance to convictions which had for some time been maturing, that not only were the Waverly rocks of the West of Carboniferous age, but that also the Chemung of New York, which Hall, White, Whitfield, Swallow, and others had persisted in identifying with these, must also be regarded as Carboniferous. I furnished a synopsis of the paleontological evidences that the Chemung, Waverly, Marshall, Rockford and Burling-

[63] Proc. Acad. Nat. Sci. Phil., September, 1862, p. 405. In the Sixteenth Report of the New York Regents Professor Hall has given figures of the internal structure of Centronella Julia, described in this paper, from drawings furnished by myself. He however, refers the species to Cryptonella—an error which he has since recognized. (Notice of vol. iv. of the Paleontology of New York, p. 21.)

[64] Fifteenth Report Regents New York, p. 198, and Amer. Jour. Sci., [2,] xxxiv, 418.

[65] Canadian Naturalist and Geol., vol. vii, p. 377.

[66] Indiana Geol. Rep., 1862, pp. 92, 108, &c.

[67] Amer. Jour. Sci., [2] xxxv, 61. In this paper, an editorial alteration makes me say "Old Red Sandstone of New York," when I wrote "Old Red Sandstone of Scotland."

ton beds were synchronous, and that all should be ranged within the Carboniferous system.[68]

In January, 1863,[69] I published a series of "descriptions of fossils from the yellow sandstones lying beneath the Burlington limestone, at Burlington, Iowa." The number of new species described in this paper was 59, and the number of old species there first identified from the yellow sandstones was 10—raising the total number of species thus far known from those strata from 66 to 135. The Carboniferous facies of this assemblage of organic remains was again insisted upon.[70]

Sir William Logan[71] in the Geology of Canada, published in 1863 or 1864, refers the Black Shale of Canada West to the Genesee, but states that Professor Hall embraces the Genesee in the Portage. This is what I had done in 1860.

In November, 1863, a pamphlet appeared from Professor Hall[72] containing descriptions of 17 species of crinoidea obtained from the Waverly sandstone series at Richfield, Ohio. While admitting that this assemblage of crinoids presents affinities with Carboniferous types, he asserts that the affinities are quite as strong with types from the recognized Chemung and even the Hamilton of New York. *Forbesiocrinus lobatus* is actually identified with a Hamilton species, while *F. communis*, though intimately related to forms from the Keokuk limestone, has also been found in the Chemung. He regards *Scaphiocrinus Ægina* as closely related also to *Poteriocrinus diffusus* of the Hamilton group. He concludes: "Left to the evidence afforded alone by the collection, and the means of comparison at present possessed, I should infer that the geological position of these species is between the Hamilton group and the lower Carboniferous beds; while the occurrence of a single species identical with a species in the middle of the Chemung group will ally them more nearly with the fauna of the Hamilton group than with that of the Carboniferous period."

The age of the Ohio sandstones was again touched upon by Professor Hall[73] in 1864, who thought that the study of the fossil plants of the Chemung tended to confirm opinions previously entertained as to the Carboniferous affinities of these rocks and those in Ohio, which he had

[68] The identifications with Chemung fossils had been reported by others; as at that time I had not personally examined Chemung specimens. I had identified one Avicula from Professor Hall's figure and description.

[69] Proc. Acad. Nat. Sci. Phila., Jan., 1863, p. 2.

[70] The genus *Syringothyris* established in this paper, though not accepted by Professor Hall, (Proc. Amer. Phil. Soc. May, 1866, p. 250) has been shown to be valid by the examinations of some of the highest authority in America and England. (See Meek: Proc. Acad. Nat. Sci., Dec., 1865, and——: Carpenter: Annals and Mag. Nat. Hist., July, 1867, p. 68, where the genus is partially illustrated-Davidson: Geolog. Mag., July, 1867, who gives a fully illustrated description of the genus—partly from drawings furnished by myself.) Dr. Carpenter now refers to this genus a part of *Spirifer cuspidatus* from Millicent Ireland (as first suggested by Mr. Meek;) *S. Hannibalensis* Swallow, *S. Capax*, Hall, *Syntrielasma hemiplicatus*, Meek and Worthen—also probably a portion of *Spirifer distans* of Belgium.

[71] Geology of Canada, 1863, p. 387

[72] Pamphlet; reprinted in xvii. Rep. N. Y. Reg., 1865, p. 50.

[73] xvi. Rep. N. York Regents, pp. 92 and 107. Note.

regarded as contemporaneous. In a note he remarks that the Catskill rocks of Eastern New York must probably be restricted to "the coarse conglomerate of the upper part of the Catskills," which corresponds to the outliers occurring on the summits of the higher hills in Western New York, and to a continuous formation beyond the limits of the State in Pennsylvania.

In July, 1865, I presented[74] a continuation of the results of my researches in the paleontology of the rocks under consideration, embracing descriptions and notices of fossils from the States of Michigan, Ohio, Indiana, Illinois, Iowa and Missouri, in all which I had made personal explorations. The number of species noticed in this paper is 94, of which 36 were therein first described. This paper presents a shadowing forth of conclusions which I feel constrained to think, demand the candid consideration of paleontologists. To this time I had been impressed with the expectation that the Chemung rocks of New York would eventually be synchronized with the Waverly series of Ohio upon paleontological grounds. It had generally been supposed that the Chemung strata embraced from three to six species which could be identified with western species from the horizon of the Waverly sandstone; and that on the completion of the study of these rocks by the paleontologist of New York, further identifications would be effected. At the suggestion of Professor Hall, I spent several days with him in February and March 1865, in making direct comparisons between the types of the Chemung group of New York and a collection of fossils supposed to belong to the same horizon, from the Western States. The western fossils brought under comparison numbered about 175 species. To the great surprise of both of us, we were unable to identify a single species with Chemung types. All the reputed identifications had to be abandoned. This is a conclusion in which Professor Hall united with myself.

Not satisfied to be completely frustrated in my attempt to determine the New York equivalent of our western sandstones, I turned my attention to an examination of the facts in connexion with strata occupying a position in Western New York above the typical Chemung strata. Professor Hall[75] had described a conglomerate in Western New York as terminating the Chemung series, and had remarked that it contained Chemung fossils; though it does not appear that any critical and final examination had been made upon this point. The Catskill group had been restricted at the east to certain conglomerates capping the Catskill mountains, and at the west to detached outliers of sandstone becoming also at times conglomeritic.[76] In addition to these he had described a conglomerate which he identified with the Carboniferous of Pennsylvania and Ohio[77]. It does not appear that any two of these conglomerates had been

[74] Proc. Acad. Nat. Sci. Phil., July, 1865, p. 109. The materials for this investigation, besides my own collections in different States, embraced Col. Whittlesey's Ohio collection and numerous residual *investiganda* of the White collection of the University, from Iowa, Missouri and Illinois.

[75] Geol. Rep. 10th Dist. N. Y., p. 252 and elsewhere.

[76] Canadian Naturalist, vii. p. 380.

[77] Rep. Geol. 10 Dist. N. Y., p, 284.

seen in juxtaposition,[78] and I am not aware of the evidence upon which they had been pronounced stratigraphically consecutive.

Through the kindness of Professor Hall I was permitted to examine the original specimens of fossils from the so-called Chemung and Carboniferous conglomerates. The fossils of the latter had been collected from a single locality, about four miles north of Panama in Chatauque county, and did not number in all more than half a dozen species, of which three had been described in the New York Report.[79] Of these, four were found, to the surprise of both of us, to be identical with species from the horizon of the Waverly series of the West.

Nor was this all. On comparing specimens of the so-called Chemung conglomerate with these, I remarked not only a great lithological similarity but a striking general resemblance of the fossils, and an actual identity of two species with species which had been identified in the Carboniferous conglomerate. My conclusions, so far as any could be reached, were announced in the following words :

"In the light of these identifications, and in the absence of all identifications between the western species and those of the Chemung, as well as between the species of this (so-called Chemung) conglomerate and those of the Chemung, it might not seem unreasonable to doubt its affinities with recognized Chemung rocks, and to suspect its continuity with the supposed 'Carboniferous conglomerate,' until observation shall have demonstrated that its stratigraphical position is really below that formamation. And further, since we must probably abandon the attempt to coördinate the Chemung of New York with the fossiliferous portions of the sandstones and shales of the West lying between the 'Black Slate' and the Coal Conglomerate, it seems not unlikely that we may yet be able to prove the conglomerate of Western New York to be the attenuated and littoral prolongation of those western sandstones and shales—at least of the superior and fossiliferous portions of them ; so that the latter would stand as a hitherto unrecognized group of strata lying at the very base of the Carboniferous system ; while the Chemung rocks of New York fall within the Devonian system, toward which the writer is now inclined to think that their paleontological affinities attract them."

"It yet remains to determine by observations in the field, whether the so-called 'Carboniferous conglomerate' of Western New York is really the equivalent of the Coal conglomerate of Ohio ; and whether any actual junction of superposition can be discovered in Western Pennsylvania or Eastern Ohio between the Chemung rocks in their westward prolongation and the fine grained sandstones and gritstones of the Western States."

In December, 1865, Messrs. Meek and Worthen[80] described three additional species from Ohio and Illinois ; and Mr. Meek[81] took up a discussion which involved the characters and validity of the Genus *Syringothyris* from the yellow sandstones of Iowa.

In 1866 I published[82] the results of a geological and economical survey

[78] Hall—Rep. Geol. 10 Dist. N. Y., p. 292.
[79] Geol. 10 Dist. N. Y., p. 291.
[80] Proc. Acad. Nat. Sci. Phil., Dec., 1865, p. 245.
[81] Proc. Acad. Nat. Sci. Phila., Dec., 1865, p 275.
[82] The Grand Traverse Region, p. 51.

of the Grand Traverse Region in the lower peninsula of Michigan, among which I alluded to the ratification of my previous opinions that the Black Shale of the West is the equivalent of the Genesee Shale. I announced here, for the first time that this shale had afforded me two characteristic New York fossils from near the mouth of Bear Creek in Canada West—*Leiorhynchus multicosta* and *Discina Lodensis*.[83]

In this report I repeated my correction that the "green shales" above the Genesee Shale in Michigan correspond to some portion—perhaps the Cashaqua Shale—of the Portage group of New York, while the higher bluish, argillaceous shales might answer to the Chemung.

In June of the same year, having occasion to make a survey and report,[84] in conjunction with Dr. Newberry, upon portions of Knox and Coshocton counties in Ohio, I cited several Waverly sandstone species as extending upward into the Coal Measures, and suggested that the Ohio equivalent of the Portage and the Chemung might be the series of the "Chocolate Shales and Flags," whose existence beneath the fossiliferous sandstones of Ohio had been demonstrated by borings. The deepest of these borings indicated the existence of 1060 feet of shales and sandstones between the base of the False Coal Measures and the top of the Genesee Shale. Of this distance 534 feet were occupied by the so-called "chocolate shales and flags."

In July of the same year Messrs. Meek and Worthen[85] described two additional species, of which one was from Richfield, Summit county, Ohio, and the other from Rockford, Indiana.

During the same year (1866) appeared the first volume of the final Report on the geology of Illinois, in which Mr. Worthen,[86] speaking of the Kinderhook group, locates it at the base of the Carboniferous system, insists upon the carboniferous affinities of its fauna, and expresses the opinion that no rocks exist in Illinois or Indiana which can be referred to the Chemung group of New York.

Before the close of the year the second volume of this Report appeared, in which the paleontology of the Kinderhook group is described by Messrs. Meek, Worthen, and Newberry,[87] the facts of which seemed fully to sustain the previous opinions of those geologists in reference to the age of the group.

During the same year (1866) Professor Hall[88] also made advance publication of some views which were to be embodied in his fourth volume of the Paleontology of New York. In this paper he insisted with great earnestness upon the probable Chemung age of the Waverly series and its western equivalents, explaining the contrast of the eastern and western faunas on geographical and hydrographical considerations.

[83] Mr. J. P. Lesley has somewhere attributed the discovery of these fossils to Professor Hall. It is true that I had exhibited them to Professor Hall and obtained his acquiescence in my identification, but he did not intimate that he previously observed them west of New York, Indeed, in his latest known opinion these Canadian shales had been referred to the Portage group. (Geology of Canada, 1863, p. 387.

[84] Prospectus of the Neff Petroleum Co., p. 7.

[85] Proc. Acad. Nat. Sci. Phil., July, 1866, p. 251.

[86] Geol. Survey Ill., I, p. 108.

[87] Geol. Surv. Ill. II, Paleont. pp. 62, 77, 80, 145.

[88] Trans. Amer. Philosophical Soc., 1866, p. 246; in advance of Vol. IV, Paleont. of N. Y.

In 1867, at the meeting of the National Academy at Hartford, Professor Hall reiterated the same views with considerable amplification. Professor Agassiz, who was present, gave them his earnest endorsement, pronouncing them the natural and philosophical conclusions of a geologist who had devoted 30 years to the study of the data upon which the conclusions rested. His remarks in reference to geologists who felt themselves constrained to entertain divergent opinions were at least emphatic, if they were not complimentary.

Finally in August, 1868, Dr. T. S. Hunt read a paper before the Chicago meeting of the American Association[89] in which he makes note of the occurrence, in the extreme western part of the province, of some gray and more or less blackish shales overlying the Genesee Shale proper, which he ranges in the horizon of the Portage group. It will be noticed in the sequel of this paper that I have made a similar disposition of similar strata in Michigan, Ohio, Indiana, Kentucky, and Missouri.

Such is a sketch of the history of opinion in reference to the rocks under consideration.[90]

III. Present State of our Stratigraphical Knowledge.

In the State of New York the strata above the Genesee Shale have been arranged by Professor Hall[91] as follows :—

Carboniferous Conglomerate :—Coarse silicious conglomerate and diagonally laminated sandstone.

Catskill Group :—Conglomerate of the Catskill mountains. Along Genesee river, a calcareous sandstone, sometimes highly ferruginous, approaching iron ore.

Chemung Group :—Conglomeritic at top in Western New York. Greenish gray sandstones with occasional fossiliferous bands.

Portage Group :—A, In Eastern New York.

1. Shales and shaly sandstones and flagstones 100 feet.
2. Red shale and shaly sandstone 400 to 500 feet.
3. Greenish and gray shales and shaly sandstones.
4. Darker shales to Hamilton Group.

[89] Published in Amer. Jour. Sci. and Arts [2] XLVI. p. 355. In this paper Dr. Hunt takes occasion to state that "Professor Winchell, for some reason, doubts the existence of the Portage formation in Ontario." As Dr. Hunt makes no reference to any published doubts entertained by me on this subject, I am at a loss to know the source of his mis-information. I have heretofore always identified with the Portage (or Portage and Chemung) the series of argillaceous strata extending from the Genesee Shale to the Marshall sandstones. (See the various references already made in this paper.) If these strata exist in Ontario I should pronounce them Portage. I have already described them upon the Michigan borders of Ontario, and it is to be presumed that they extend across the boundary. As Dr. Hunt states, these Portage shales are physically a continuation of the Genesee shale proper, and by ranging them all in my Huron group, I did in 1861, what Dr. Hunt has done in in 1866 and 1868.

[90] I have made no note of the elaborate and able researches of Dr. Dawson upon the fossil vegetation of rocks lying in and near the zone under consideration. Dr. Dawson's papers—together with some minor papers, also passed over—will be referred to in an Appendix.

[91] Final Rep. IV Dist. N. Y.; Canadian Naturalist and Geologist, vol. vii., p. 377; xvi. Report Regents N. Y., p. 107. Note.

B, In Western New York.

1. *Portage Sandstone*, thick bedded.
2. *Gardeau Shales and Flagstones*—green and black—slaty and sandy shales with thin layers of sandstone.
3. *Cashaqua Shale*—soft, argillaceous, green, crumbling to a tenaceous clay.

In Ontario, although Professor Hall and Sir William Logan have assigned at least a portion of the black shales to the horizon of the Portage Group, I have not been able to distinguish any of them from the Genesee shale proper containing *Leiorhynchus multicosta* and *Discina Lodensis*. As overlying shales of the age of the Portage Group however exist in Michigan close to the national boundary, I have always presumed that they extend across it. This opinion Dr. Hunt has very recently confirmed.

In Michigan I have been able to make out a complete determination of the strata as follows:[92]

Parma Conglomerate:—a whitish or rusty, often conglomeritic and obliquely laminated sandstone with vegetable remains. 105 feet.

Carboniferous Limestone:—irregularly bedded, often cherty or ferruginous, and much shattered *in situ*—becoming arenaceous below. 70 feet.

Michigan Salt Group:—consisting of aluminous and gypseous shales, thin gray flags, bands of limestone and thick beds of gypsum. 200 feet.

Marshall Group:—consisting of:—

Napoleon Sandstone, pale buff, often conglomeritic, obliquely laminated, thick bedded. 123 feet.

Marshall Sandstone, reddish, yellowish, olive, obliquely laminated, highly ferruginous—the iron often under a rudely concentric, concretionary arrangement. In places calcareous. Highly fossiliferous. 160 feet.

Huron Gritstones, bluish or greenish gray, fine grained, regularly bedded. 15 feet.

Huron Group, consisting of:—

Argillaceous shales and flagstones—the latter less prominent in the southern part of the State. 500 feet.

Green arenaceous shales, especially in Grand Traverse Bay. 25 feet.

Black bituminous shale (Genesee shale). 25 feet.

Hamilton Group. [The calcareous member of this group is conspicuous in Michigan.]

In the State of Ohio the succession of strata seems to be nearly as follows:[93]

Conglomerate, buffish, obliquely laminated, more or less pebbly, often with rudely concentric spheroids of iron ore. Sometimes underlaid by "False Coal Measures."

[92] Mich. Geol. Rep., 1861, p. 138; Amer. Jour. Sci. [2] xxxiii., 352; The Grand Traverse Region, p. 49.

[93] Foster Geol. Rep. Ohio, p. 77; Briggs—Ib., p. 79; Whittlesey—Proc. Amer. Assoc. v. p. 76; Winchell—Mich. Geol. Rep., 1861, p. 78, also, Prospectus, Neff Petroleum Co., p. 7.

Gritstone series, consisting of flaggy shales, ferruginous, somewhat thick-bedded sandstones with iron-stone partings, often with interstratified blackish or bluish shales. Followed downward by shales of a bluish, brownish or reddish color, 100 to 150 feet.

Waverly series:—Bluish or greenish gray, fine-grained and evenly bedded, often fossiliferous sandstones and flags, with interstratified brownish shales. 200 feet. [In Knox county the Gritstone and Waverly series are together 517 feet.]

Chocolate shales, argillaceous, chocolate colored, bluish and blackish. 250 to 300 feet. [In Knox county this series is 450 feet.]

Black Shale, 100 to 150 feet. [This is an abnormal thickness of the Black Shale in the West, and it is probable the upper portion belongs with the Chocolate series.]

In the State of Indiana the series seems to be constituted as follows:[94]

Carboniferous Conglomerate.

St. Louis Limestone, freely represented.

Warsaw Limestone.

Keokuk Group, consisting of:—

Gray limestone and calcareous shales (Floyd county) 50 feet. Wanting in Northern Indiana.

Brown shales with geodes and nodules of hornstone.

Knob formation or gritstones, micaceous, ferruginous, friable, with intercalated limestones in the upper part. 150 feet or more.

Rockford Limestone, with Goniatites, &c.; represented by a thin bedded sandstone in Northern Indiana. Wanting in Western Indiana.

Black Shale.

In the State of Illinois we have the following succession of strata.[95]

Burlington Limestone.

Kinderhook Group, consisting of "gritstones, sandy and argillaceous shales, with thin beds of fine-grained and oölitic limestone." 100 to 200 ft.

Black shale. "Dark blue, green, or chocolate colored shales, passing locally into a black bituminous shale." [Presents in Southern and Western Illinois, rather the characters of the Huron shales of Michigan. May it not constitute, with the lower portion of the Kinderhook group, a representation of the Portage and Chemung of New York?]

In Iowa (at Burlington) the series of strata is the following:[96]

No. 8. Upper Burlington Limestone. 20 feet.

No. 7. Lower Burlington Limestone. 30 to 50 feet.

No. 6. Oölitic Limestone, with fossils. 2 feet.

No. 5. Yellowish Sandstone with abundant casts of Brachiopods. 4 to 6 feet.

No. 4. Limestone, with Brachiopods. 9 feet.

No. 3. Oölitic Limestone. 3 in.

[94] Hall—Trans. Assoc. Amer. Geol. p. 280; Meek and Worthen—Amer. Jour. Sci. [2] xxxii., 167; Worthen—Ill. Geol. Report, vol. i., p. 116; Christy—Proc. Amer. Assoc., v., p. 76.

[95] Worthen—Geol. Surv. Ill., I., p. 108; III., p. 115.

[96] Hall—Iowa Geol. Rep., I., 90; White—Ib., Append.

No. 2. Bluish-brown Limestone with corals. 8 in.
No. 1. Yellowish Sandstone, passing downward into a bluish indurated clay. Fossils rare. 68 feet and more.

In Missouri we are furnished with the following series of rocks:[97]
Encrinital Limestone, regarded as equivalent to the Burlington Limestone.
Chouteau Limestone. 10 to 70 feet.
Limestone, brownish-gray, earthy, silico-magnesian, in thick beds. 40 to 50 feet.
Limestone, blue or drab, compact, thin and irregularly bedded.
Vermicular Sandstone and shales. 30 to 100 feet.
Sandstone, buff or yellowish-brown, fine-grained, argillo-calcareous. Sometimes becomes an impure magnesian limestone.
Shale or fire-clay, blue or brown, argillaceous, in regular, thin strata.
Lithographic Limestone, light drab to light buff and blue, pure, fine, compact, even-textured, silicious. 60 to 70 feet.
At bottom is a blue shale 30 to 40 feet thick.

In Kentucky, according to my own observations, we have at Knob Lick and Pine Knob, four miles south of Danville, the following section:
Sandstone, yellowish, from top of Knob down. 150 feet.
Shale, blue, arenaceous, with bands of iron ore and ferruginous sandstones, forming the phenomenon known as "Knob Lick." 80 feet.
[Resembles shales of Huron Group.]
Black Shale, only moderately bituminous. 40 feet.
Silicious and Geodiferous Beds, containing *Cystiphyllum Americanum*, *Phillipsastræa gigas*, *Heliophyllum Halli*, *Fistulipora Canadensis* and other Hamilton fossils.[98]
Hydraulic Limestone, blue, arenaceous, very thick bedded, with fragments of fossils. 12 feet.
Nashville Group.

In Tennessee the Black Shale rests directly upon the Nashville group, and is overlaid by about 150 feet of the "Silicious Group," in the very lowest beds of which I have recognized *Producta semireticulata*, *Orthis Michelini*, *Spirifera Logani*, and an undescribed *Zaphrentis*, which, with the *Spirifera*, is regarded as characteristic of the Keokuk Limestone.[99] Above the Silicious group we have 394 feet of cherty limestone, mainly referable to the St. Louis division,[100] since it contains *Lithostrotion Canadense*, *Producta semireticulata*, *Streptorhynchus umbraculum*, *Spirifera Keokuk* Var, *S. perinflata?* The presence of *Rhynchonella Verneuiliana* indicates that the Warsaw limestone may also be represented in the lower portion of this formation. Next above we have 603 feet of limestone abundantly

[97] Swallow—Neo. Geolo. Report, I., 101 and Tab. 15, p. 99; Meek and Worthen—Amer. Jour. Sci. 2] xxxii., 171.

[98] D. D. Owen speaks of no Devonian in this part of Kentucky except the Black Shale. He, however, speaks of Upper Silurian rocks; these I have not seen.

[99] These fossils were collected in Hickman and Maury counties, and kindly furnished me by Prof. Safford.

[100] In its physical characters this cherty limestone is a continuation of the Silicious Group, and Prof. Safford informs me that he so treats it in his forthcoming Report.

stocked with the crinoids of the Kaskaskia division of the Mountain limestone, embracing *Pentremites Godoni, pyriformis, symmetricus* and *globosus* and *Agassizocrinus gibbosus*. This section is from the eastern border of the basin of Tennessee along the road from Nashville to Sparta and the summit of the Cumberland Table Land at Bon Air.

A black bituminous shale exists in considerable force in Carrol county and other parts of Arkansas, immediately superimposed by lower carboniferous limestones; but Dr. D. D. Owen expresses a doubt whether it answers to the Devonian Shale of Ohio; and he also doubts the existence of rocks in Arkansas corresponding to the Knob formation.[101]

In attempting to trace the parallelism of these formations on purely structural and lithological grounds, it may be remarked, in the first place, that the identity of the Black Shale cannot now be mistaken. It is a matter of no surprise that it should at any time have been referred to the horizon of the Marcellus Shale, as long as stratigraphical observations were confined to Ohio and Indiana. Its stratigraphical position above the Hamilton group is now, however, demonstrated by actual superposition in Grand Traverse Bay of Lake Michigan, Thunder Bay of Lake Huron, at various points in the peninsula of Ontario, and on the borders of the "Knob region" below Danville in Kentucky. Its position immediately below the arenaceous and argillaceous beds which are the subject of discussion in this paper, is demonstrated by the order of superposition at Pt aux Barques of Lake Huron, at sundry points in Branch, Kalamazoo and Allegan counties, Michigan, and at various places in northern and central Ohio. When at Rockford, Indiana, I had the opportunity to make my observations under favorable circumstances. The milldam had been broken away by a freshet, and the exposure of Black Shale three-fourths of a mile above was such as to indicate clearly by the dip, that this rock passes under the Goniatite limestone. My observations in this vicinity enabled me to determine the following succession of strata.

Goniatite Bed—seen below the dam and at Wilson's creek.

Semi-indurated clay.

Limestone, fine, compact but shattered, bluish, rusted in the vicinity of the fractures. Contains the Brachiopods and Radiates described from Rockford.

Black Shale.

It is further possible, as first suggested by Messrs. Meek and Worthen, that the blue shale at the base of the Lithographic Limestone in Missouri should be co-ordinated with the Black Shale. I think, however, there are reasons for considering the Genesee Shale unrepresented in Missouri.

It is proper to remark that the so-called Black Shale or "pyroschist"[102]

[101] Geology Reconnois. Ark. I, pp. 87, &c., and 135.

[102] Dr. T. S. Hunt proposes this Anglicised Græcism of the "Brandschiefer" of the Germans, (Amer. Jour. Sci. [2] xxxvi., 159,) since, as he asserts, this shale contains no free bitumen. In this, however, he is certainly mistaken, as I have seen it oozing from the cliffs in Grand Traverse Bay; and I am informed that the odor has sometimes attracted the attention of travelers. It appears, furthermore, that the intimate mingling of comminuted organic matters with argillaceous materials creates the most favorable conditions for the spontaneous evolution of hydrocarbonaceous products from the rocks.

varies very materially in the percentage of bituminous and carbonaceous matters at different localities; and the thickness of the dark bituminous beds is also extremely variable. In Michigan and Tennessee the bituminous beds are comparatively thin, but in the former State there is a vast mass of non-bituminous or slightly bituminous shales immediately overlying the lower portions, which pass by insensible gradations into the typical black shale. These, according to Hunt, occur also in Ontario. Proceeding from structural data alone, I united this entire series of shales in one formation which I styled the Huron group; and I am even now strongly inclined to associate this shale with the strata above rather than with those below. Should it be thought these facts tend to point out the equivalency of the Black Shale proper with the dark shales existing in the lower part of the Portage group of New York, it may be stated that the existence of *Lingula spatulata* in great abundance in the Black Shale of Ohio and Kentucky and the presence of *Discina Lodensis* and *Leiorhynchus multicosta* in the Black Shale of Ontario will effectually narrow the determination to the Genesee Shale of New York.[103]

In the next place, the Carboniferous Conglomerate marks a superior horizon which cannot ordinarily be mistaken. The Parma Conglomerate of Michigan, as I have heretofore indicated,[104] occupies the same stratigraphical position. The conglomerate of Western New York identified by the New York geologists with the Coal Conglomerate of Ohio, presents undoubtedly a lithological affinity. The same is true, however, of the conglomerate represented as terminating the Chemung series, and also of the conglomeratic portions of the Catskill group. I am not informed of the lithological or structural grounds upon which these three similar conglomerates (each locally varying to similar sandstones) have been ranged in an order of sequence. As they are nowhere seen in immediate superposition, it is at least supposable that they are but local occurrences of one and the same formation. If thus identifiable, the question still remains to be determined whether the formation lies in the horizon of the Chemung, in that of the Catskill or that of the Coal Conglomerate. The only evidence at present in our possession bearing upon the determination of this question is paleontological. This evidence, as I have already intimated, tends to unite the so-called Chemung and Carboniferous conglomerates and range them in a zone below the Coal Conglomerate of Ohio. This subject will be resumed in the paleontological part of this paper.

In the third place, it may be remarked that we are now in possession of the means of determining the parallelism of the western strata between

[103] I desire to remark, in passing, that the Marcellus shale of New York is probably represented in Little Traverse Bay by the highly bituminous and earthy limestone near the base of the Hamilton group. The same is seen at Thunder Bay Island, Lake Huron, and in the oil wells of Enniskillen, Ontario. This shale seems therefore, like the Genesee shale, to constitute only an appendage to another formation.

[104] Michigan Geol. Rep., 1861, pp. 114, 138. So far as I know this was the first instance in which a geological designation was bestowed upon this formation. The Canadian geologists in the Report of 1863, apply the name "Bonaventure formation" to a series of arenaceous strata "belonging to the base of the Carboniferous series." (p. 404.) In the Atlas to accompany this Report, published in 1866, the Bonaventure formation is put down as the equivalent of the Coal Conglomerate of the United States.

the Carboniferous Conglomerate and the summit of the arenaceous series which has been locally designated Waverly, Marshall, Kinderhook, &c. The Carboniferous limestone of Michigan has been shown [105] on paleontological grounds to possess affinities with the median stages of the Carboniferous Limestone series of the Mississippi valley. The Michigan Salt Group has at length yielded some beds of fossiliferous flags, from which, as might have been anticipated, it is shown to stand in close relation with the same series. The Knobstones of Indiana and Kentucky, always ranged by geologists within the limits of the Carboniferous system, possesses strong lithological affinities with the Waverly series, and withal occupy the same relative position between recognized Carboniferous limestones and the Black Shale. But paleontological evidence compels us to elevate them into the zone of the Mountain Limestone which, at every point of contact, is shown to lie above the Ohio psammitic series. Indeed, it appears from observations made by others and by myself, that the Knobstone formation of Indiana and Kentucky, with the associated shales and limestones, is substantially restricted to the horizon of the Keokuk division of the Mississippi Limestone series, or "Mississippi group."[106]

The Silicious group of Tennessee is only a southward prolongation of the same under changed petrogenetic conditions; though in that State, the silicious characteristics also invade the horizon of the Warsaw and St. Louis Limestones—as may be seen along the valley of the Calfkiller river, and on the first bench of the ascent to the Cumberland Table Land.

We come now to the series of strata, the determinations of whose equivalencies has presented the most serious difficulties. The Gritstones and Waverly sandstones of Ohio offer marked petrographic affinities with the arenaceous strata of the Chemung and Portage groups of New York; and it is doubtful whether on purely lithological and structural grounds we should ever be able to distinguish them. The same may be said however, and has been said, of the Knobstones of Indiana; and the same is also measurably true of a comparison between the Chemung and Catskill strata, or the Catskill and Millstone Grit, or the Waverly and Millstone Grit. There seems to be, moreover, a connection of continuity between the psammites of Ohio and the Chemung flags of Chatauque county. A similar petrographic resemblance is apparent between the Marshall rocks of Michigan in the northern and southern outcrops, and the Waverly of Ohio. Furthermore, no little resemblance can be traced between these sandstones and the yellow sandstones beneath the Carboniferous limestone of Iowa. The Rockford limestone and the calcareous strata of the same zone in Illinois and Missouri present considerable contrast, but they approximate, on the other hand, certain calcareous beds in the Waverly series of Summit county, Ohio, and the Marshall series of Calhoun county, Michigan. Moreover, these calcareous strata are intimately associated in Illinois and Missouri, with arenaceous strata which everywhere recall the aspect of the arenaceous strata of other States. In respect to stratigraphi-

[105] Mich. Geol. Rep. 1861, p. 103.

[106] I propose the use of this term as a geographical designation for the Carboniferous Limestones of the United States which are so largely developed in the valley of the Mississippi river.

cal position, we find all these formations lying beneath the Mississippi limestones and above the Genesee shale.

The synchronism of the Waverly and Gritstone series of Ohio, with the Portage and Chemung of New York, has not only long been asserted—at least at invervals—by Professor Hall, but has been generally assented to by others, who have had occasion to consider the subject, or have felt disposed to defer to competent authority. The controversy which has existed has been rather in reference to the systemic position of the two, as the citations which I have already made from the history of the controversy sufficiently indicate. The Waverly series has generally been regarded of late years, as extending down to the Black Shale; and the denial of the parallelism of this series with the Chemung and Portage has appeared to leave no space for the existence of the latter groups in Ohio. There is, as Professor Hall has frequently asserted, an improbability that a group more than a thousand feet thick in western New York, should have completely thinned out before reaching the meridian of Cleveland or the peninsula of Michigan. There are some facts in my possession, however, bearing upon this subject, which I have never yet had the opportunity to bring into prominent notice.

In my Report on the lower peninsula of Michigan I described a series of argillaceous strata[107] underneath the Marshall sandstones, and extending to the Hamilton limestones. The Genesee Shale constitutes the lower portion of this group—being structurally a portion of it. In my Report I assign but 210 feet of thickness to this group, as this was all that I had actually measured at outcrops; but borings subsequently executed in various parts of the State, show that the group actually possesses a thickness of 500 to 600 feet.[108] This mass occupies the place of the Portage and Chemung strata. In the southern portion of the State it is quite purely argillaceous, passing vertically at intervals into micaceous arenaceous shales, or even calcareo-arenaceous flags; but in its northern outcrops, we find compact flagstones frequently intercalated in the series, giving it a physical approximation to the New York strata, whose stratigraphical position it usurps. Moreover, in Grand Traverse Bay, we discover, not far above the Genesee Shale, a mass of green arenaceous shales which apparently answer to the Cashaqua Shale of the Portage group.

We have in this series all that is requisite to answer the demands of the Portage and Chemung groups. The thickness is, indeed, considerably reduced; but it must be remembered that all the other New York groups traced into Michigan exhibit even a greater attenuation than this parallel would imply.[109]

[107] I embraced in this group 14 feet of gritstones, which I subsequently removed, on studying their paleontology. (Amer. Jour. Sci. [2] xxxiii., 352.

[108] I have several times published these later determinations, but Dr. Hunt continues to quote from my Report of 1861, (Amer. Jour. Sci. and Arts, xlvi., 357,) having evidently overlooked my later announcement. (See, for instance, "The Grand Traverse Region," (1866) p. 52.)

[109] Dr. Hunt thinks the Salina Strata will yet be found to attain a greater thickness in Michigan than that assigned to them in my Report of 1861, (Amer. Jour. Sci. and Arts, xlvi., p. 359.) The facts announced by him would certainly justify such an expectation; but I embrace the opportunity to state that though bored through in several places since the date of my Report, the thickness has not been found materially greater than stated in 1861.

Let us now inquire whether in Ohio, which lies contiguous to Michigan, anything can be discovered which answers to the Huron group. The lower portion of the series super-imposed upon the Black Slate of Ohio, has generally been passed by with the remark that it appears to be unfossiliferous, or that it *may* belong to a different epoch from the fossiliferous sandstones above. I think, however, the thickness of these subter-psammitic strata has not been generally suspected. As in Michigan, so in Ohio, we are indebted to the enterprise stimulated by the late petroleum-industry, for the disclosure of the full extent of the argillaceous and flaggy deposites immediately above the Black Shale. We are now assured of the existence of a vast series of shales in Ohio which correspond both in position and in lithological characters to the Huron group of Michigan. In Knox county they attain a measured thickness of 450 feet. Here, again, we discover ample scope of strata to answer the demands of the New York Portage and Chemung, without bringing in the Waverly and Gritstone series above.

In Kentucky also, at "Knob-lick," south of Danville, and at other points, we discover a series of argillaceous strata not less than 80 feet thick, reposing upon the Black Shale, and presenting again all the physical characters of the Huron group. As these shales are surmounted by Knobstones of Keokuk age, we have no stratigraphical determination whether they should be synchronized with the Huron group, or the Marshall, or the lower part of the Mississippi group. I think it will be admitted, however, that some presumption exists that they lie in the horizon of the Huron Shales.

In Iowa it seems not unlikely that the base of the yellow sandstone series, with its bluish, slightly micaceous sandstones, comes into the same zone; while the blue shales, 80 feet thick, beneath the Lithographic limestone in some parts of Missouri, may probably be more correctly synchronized with the argillaceous shales of the Huron group than with the black or Genesee section of that group. I would suggest also that the Illinois shales, somewhat doubtfully referred by Prof. Worthen to the horizon of the Genesee shale, may lie rather in the horizon of the Huron shales of Michigan.

It appears from the foregoing statements that we are by no means compelled to resort to the Waverly and Marshall series to discover the western representatives of the Portage and Chemung of New York. If the apparent continuity of the eastern and western formations should appear to compel such identification, let it be remembered that the Knobstones stand in the same apparent relation to the Waverly that the Waverly does to the Chemung, and yet we yield to the weight of paleontological evidence in denying their equivalency. If, moreover, it appears that the Chemung and Portage have become finer and more argillaceous in their westward extension, it will be remembered that the Waverly strata also, when traced into Indiana, Illinois, and Missouri, have assumed a finer constitution, and have received moreover that accession of calcareous constituents which we always expect to characterize formations remoter from the

ancient continental shores.[110] During the periods which followed the Genesee epoch, the time was approaching when the agitations of the terrestrial crust should culminate in the spread of thousands of square miles of coarse *débris* over the bottom of the continental lagoon of North America; the materials of the great Carboniferous Conglomerate. In the progress of the gathering convulsion, the movement of the waters had attained such a degree of violence during the period of the Portage and Chemung as to give rise to the formation of flags and sandstones within the limits of the State of New York, while yet the quieter waters which rested over Michigan and Ohio were precipitating only the materials of shales, and the regions further west were as destitute of mechanical sediments as of the organic *débris* which give origin to limestones. In the following or Marshall period, the disturbance of the terrestrial crust had attained such a limit as to give distribution to the Catskill and so-called Chemung and Carboniferous Conglomerates of New York, while in Ohio and Michigan, it attained only such a degree of energy as had been witnessed in New York during the preceding period, and resulted in the sandstones and shales of the Waverly and Marshall series. Still further West the quiet conditions of limestone-making continued to prevail. In the Knobstone epoch following this, the agitation had extended still further West. While 3,000 feet of mechanical sediments were accumulating in Pennsylvania, the conditions of sandstone accumulation had traveled towards the centre of the American lagoon as far as Indiana, Kentucky and Tennessee, while even yet, the state of quiet was sufficient in Illinois and west of the Mississippi to permit the existence of limestone making animals. The grand agitations of the Millstone grit epoch followed, with the still later oscillations of the surface which conditioned the phenomenon of the Coal epoch, terminated by the tremendous convulsions which gave birth to the mountain barriers of the Atlantic border. But none of these events were felt in the far West. Deep seas and limestone-forming operations—as Prof. Hall has well shown[111] continued to characterize the history of the interior of the continent while the coal marshes of Ohio and Pennsylvania were heaved and tossed in the titanic pastimes of geological forces.

This sketch of the succession of geological events shows that the parallelism which I have traced is in strict harmony with the method of later Paleontological Time; and instead of suggesting abrupt disappearances and incongruous synchronisms, is the only marshalling of the American strata which keeps perfect time with the grand march of geological events.

[110] There is *a priori* evidence against the continuity of the Chemung and Waverly. Arenaceous sediments, from the circumstances and conditions of their origin, must be limited in extent, at least in one direction. We should therefore *expect* the Chemung to grow finer and to lose its physical identity in its western prolongation; and, if a sandstone recurs at the West, the immediate *presumption* arises that it is a phenomenon of changed continental conditions, characterizing another geological period. Compare Hall: Foster and Whitney's Rep. II, p. 287.

[111] Report on the Geol. and Pal. Mex. Boundary Surv. p. 124; Iowa Geol. Rep. p. 137—141.

Stated Meeting, March 19, 1869.

Present, ten members.

JOHN C. CRESSON, Vice-President, in the Chair.

Letters accepting membership were received from C. L. Rütimeyer, dated Basel, February, 18th, and from J. Prestwich, dated Shoreham, near Seven-oaks, England, March 2, 1869.

A letter of envoy was received from the Meteorological Office of the Royal Society at London, dated Dec. 24, 1868.

Donations for the Library were received from the Meteorological Office of the Royal Society of London, from M. Chevalier, Membre de la Commission de l'Exposition Internationale de 1867 at Paris, from the London Board of Trade, from the Boston Natural History Society, from the American Antiquarian Society at Worcester, from the Editors of the American Journal of Arts and Sciences at New Haven, from Prof. Cook, State Geologist of New Jersey, at Newark, from Mr. Henry C. Carey, Mr. Pliny E. Chase, and the College of Pharmacy, at Philadelphia, and from the Smithsonian Institute, at Washington.

Commodore John Marston presented, for the cabinet, four fragments of painted pottery, dug up by him, early in the year 1861, from the soil of the Island of Sacrifices, near Vera Cruz, Mexico.

The principal piece is 5 inches long by 2 inches wide, a sort of doll, with a fillet over the head, and a painted white plain ribbon-like collar round the neck, from which seems to have depended six painted white and red tags, four on the breast, and one behind each shoulder. The fillet over the forehead is painted in alternate red and white sections. The skin of the forehead and nose, the region around the mouth, the lower parts of the ears, and the half-seen eyeballs, are painted the same dead white; the rest of the doll has been painted a deep red, much of which has worn off. Two banded bent arms can be traced down the sides and upon the breasts, ending in two white spots for hands. An attempt has been made to signify the left arm by a slight relief. The head has the Astec monument look, there being nothing but backhead and forehead. The eyes are half closed, and the upper teeth exposed by the drawing back of the upper lip. This gives the impression that it was intended to represent a corpse or

mummy. Two small holes show that the cylinder is hollow ; but they do not communicate.

One of the other three pieces is a whistle, made of a human head without neck, the aperture slanting up over the forehead. The cheeks are hugely swollen, and the mouth set to represent the act of blowing. The nose is colossal, and the whole thing full of that peculiar humor of Mexican art, which is so strikingly exhibited in the set of masks (?) which the Society has in its Poinsett Cabinet.

The other two fragments are very imperfect, and seem to have been pipe-stands, ornamented, the one with a bird's head, and the other with something like a calf's.

Judge Cadwalader read, by appointment, an obituary notice of Mr. Bancker, which was followed by remarks by Mr. E. K. Price, describing the consequences of the policy inaugurated by Mr. Bancker, as President of the Franklin Insurance Company, of holding a large number of small mortgages. To the encouragements and facilities which this policy affords mechanics and builders with small capital, and, therefore, to Mr. Bancker, the City of Philadelphia has been largely indebted for its rapid extension.

Dr. Emerson communicated a description of an ingenious and important improvement in Whitney's Cotton Gin (1793), made by Mr. R. R. Gwathmey, of Kentucky (1867), and already adopted by planters in the Southwestern States.

Whitney's gin requires the cotton to be picked by hand from the boll, before it can be ginned. Gwathmey's machine, by simply reversing the motion of the saws, rejects the hulls unbroken, and thereby increases the working capacity of a field hand fourfold, that is, from the old rate of five bales of (400 lbs.) per month to twenty.

Pending nominations Nos. 622 to 626 were read.

The Chairman of the Special Committee on the Letting or Selling of the Hall reported that the Committee desired the advice of the Society respecting price. In view of the small attendance of members, on motion, this subject was made the order of business for the next meeting, notice to be sent to all the members.

On motion of Prof. Trego, the subject of the Rittenhouse Clock was referred to the Curators, with power to act, reporting their action to the Society.

And the Society was adjourned.

OBITUARY NOTICE OF MR. BANCKER BY JUDGE CADWALADER.

CHARLES NICOLL BANCKER, one of our oldest members, died on 16th February last, aged 91 years. The Society's request that I would prepare their memorial of him is fulfilled with a mournful pleasure. But my domestic connection with him was so close that the duty cannot be performed without a feeling of some embarrassment. The spontaneous tendency to the language of eulogium will be restrained.

I will not here speak of him in his religious or social relations. My remarks will be limited to subjects which may concern more directly his relations to our Society.

We may thus consider the career of Mr. Bancker as a merchant on an extended scale, as a practical and scientific insurer, and as a man of general scientific information.

New York, the city of his birth, was, in the days of his youth, a place of secondary importance. He removed, in his boyhood, to Philadelphia, then the commercial, political, and literary metropolis, where he entered the counting house of John Guest, one of the largest importers from England, and was thoroughly educated for the pursuit of commerce. Before he had completed his twenty-first year, he became, through his abilities, energy, and assiduous efficiency, the partner of Mr. Guest, who changed his residence to England, leaving their vast concerns here in the sole charge of his young associate. This was Mr. Bancker's responsible relation for many years, including the latter part of the first war, and a great part of the second war, of the French revolution. In each of these eventful periods, the commercial navigation of the world was, in a great measure, carried on under the flag of the United States. The opposing belligerents asserted that the cargoes, professedly of neutral ownership, in vessels thus navigated, were of more than twenty times the greatest value that could be honestly owned by neutrals. The retaliatory maritime hostilities of the opposing belligerents against professed neutrals were chiefly directed against the United States. Cruisers and privateers captured our vessels and those of avowed enemies almost indiscriminately. Such were the causes of the maritime war of the United States with France in 1799, and of their general war with England in 1812.

I believe that Mr. Bancker's house in trade owned no vessels, and neither imported nor exported merchandize for the account of others. The immense business in which they were engaged for their own account required the purchase of millions of sterling bills. This important part of their business was conducted so regularly and carefully that not a penny was ever lost from the failure of parties to such paper. The fact is remarkable, and the reason is interesting. It was not that parties to the paper did not fail. Many failures of course occurred. Of perhaps five sets of Exchange, three, or even four, through capture, might not reach their destination. But there was no loss, for the reason that Mr. Bancker's

house took no bills which they did not, on sufficient grounds, believe to have been drawn upon shipments, or intended shipments, of adequate value. His house were mere buyers in the exchange market. They did not themselves take, or directly control, any security except the personal responsibility of the drawers of the bills. But this was not the security on which they relied. Believing that the business in which every bill had been drawn was legitimate, they had no doubt that the bill would be accepted abroad, upon the credit of shipments which had been, or would be *fully insured* against capture.

Capricious vacillation marked the belligerent conduct of the British Government in the occasional suspension and renewal of ill judged retaliatory measures affecting neutrals. A sudden commercial crisis, from one of the most ill-timed of these vacillations, caused, in 1810, an unprecedented depression of the values of a large stock of British imports in the United States. The heaviest losers were Guest and Bancker. The partnership was dissolved. He retired from it, without retaining any property, but was not indebted to any one.

During the interval which preceded the war of 1812, he visited England on business of Stephen Girard, then the wealthiest merchant of the United States, with results of extraordinary profit for Mr. Girard, and of corresponding advantage to himself. He soon resumed commercial business on his own account, and continued it variously for several years. At one time, he dealt largely in cotton, including the product of the remotest parts of our country in which it was grown. His practical experience in almost all subjects of internal and external trade, was of the most extended range.

He was not engaged in commerce after 1826. It then became necessary for him to seek other employment; and his attention was turned to insurance.

The science of insurance—for it *is* a science—cannot be sufficiently taught by professors of law, nor fully understood by mere merchants, nor very deeply fathomed by mere mathematicians. Insurance, we may be told, is a substitute for capital, and should enable men without capital to engage securely, on borrowed means, in enterprises otherwise unduly hazardous; and, therefore, that where insurance has been made, and the premium paid, anything which may tend to prevent fair indemnification against loss, ought in law to be deemed a breach of contract, and must in ethics be a subterfuge and fraud. On the other hand, we may be told that the contract is one of indemnity against a risk of which the subject is always beyond the insurer's reach or control, and is at the exclusive charge and disposal of the insured; that the insurer is therefore entitled always to expect a rigid application of the purest principles of ethics for the protection of his interests, and that no public interest would be promoted by excusing a careless disregard of his rights. Each proposition, when correctly understood, may, with certain applications, be true. But neither proposition is of much practical use. In the absence of fraud,

persons insured do not ordinarily forfeit their insurances through any mere carelessness of themselves or their agents. But *no prudent insurer will take a risk where any interest of the insured would be promoted by carelessness of the subject* of the risk. Insurance, it has again been often said, is an *aleatory* contract, that is to say, a bargain upon a chance, like a throw of dice. An insurer's tables of risks may, in a certain sense, resemble those which might be made for the use of a professional gamester on a grand scale. But beyond this, there is properly no analogy to gaming. Insurance, in its general results, is, in fact, though not in form, a contract of mutual benefit; and the benefit is not, in any proper sense, *uncertain* upon either side. The values of life insurances can thus be calculated with approximate certainty, because, however uncertain may be the continuance of an individual life, the *average* duration of human life, is known from experience, and is almost invariable. Then, as to marine insurances, it has been often said with truth, and, in our own city, has been practically tested in more cases than one, that a merchant employing a great many ships, or shipping a great many cargoes, may prudently calculate for himself whether he would more probably lose by insuring than derive benefit; in other words, whether the premiums to be paid would probably exceed the maritime losses to be incurred.

Fire Insurance, under this head, is not an exception. Where the risks are sufficiently numerous, at points detached from one another, and of small amounts, or where large risks are divided among several insurers, the rates of premium are safely adjustable to a standard of uniformity. The more the insurances are with due caution multiplied, and the source of profit increased, the greater is the safety of the insurer. These are truisms, whatever may be the complexities of their safe application. I will not add any general remarks concerning the reservation and investment of accruing income to meet losses.

It is a misfortune of the present age, and an especial evil in this country, that men do not scruple to engage in responsible business, without any apprenticeship, or other preparatory training. An insurer without experience would be not less unfit for the business than a landsman for navigation. In Mr. Bancker's time, interests of importance were not thus trusted in untried hands. His youthful experience of marine insurance had been acquired when it was principally the business of underwriters not incorporated. It had been regulated by them on the sound basis of self interest. The insurance of his own shipments may have been instructive to him, but had probably been less so than his necessary constant observation, during the wars of the French revolution, of the transactions of other merchants, whose bills he purchased when the safety of his remittances depended upon the insurances of millions in value of shipments afloat, whose dangers have been mentioned under a former head. He had afterwards been, for some years, the agent, in this country, of one of the largest associations of English insurers; and had been a director of a life insurance company in this city. Fire

insurance was the branch of the business in which he proposed specially to engage. To the preparatory study and observation of the peculiarities of insurance of this kind, he devoted more than two years until 1829, when, through his influence, the Franklin Fire Insurance Company was incorporated. He conducted this Company's business for almost forty years.

At his death, the Company, with an entire capital of $400,000, had paid five-and-a-half millions of losses, and the claims unsettled were less than $24,000. The annual income was $360,000, or 90 per cent. on the capital. The yearly dividends for ten years had been 32 per cent.; and the assets were more than $2,600,000,—the accrued surplus being about $1,100,000. Nothing had ever been lost upon an investment; nor was there an existing investment of doubtful security. This complete success of the Company was due entirely to his administration of its affairs.

The attainment of such success, or of much greater seeming success, would not have been surprising, or even extraordinary, if there had, in the meantime, been a corresponding hazard of proportional heavy losses. But such hazard had not been incurred. At the outset, serious difficulties were indeed encountered in promoting the extension of the new Company's business without assuming an undue proportion of extra-hazardous risks. Of risks of small amount in Philadelphia, most of the less hazardous were taken by two or three mutual insurance Companies of long established standing, which made no dividends. Competition for such risks, at full premiums, could not be expected until a corresponding surplus fund, in addition to the capital, should have been accumulated. The division of large risks among several insurers was then difficult, if not impossible, because fire insurers, and fire insurance agencies, were few, and fire insurance brokers fewer. Upon manufacturing establishments and the contents, insurances might readily have been effected. But there could be no standard of premiums on such risks uniformly proportional to the actual hazard, because, independently of the combustibility of the subjects, and of general reasons which under a legislative policy of artificial protection affect such risks, the constantly recurring changes in the protective legislation of the United States made the inducements to care of such subjects by the parties insured peculiarly variable. These early difficulties were for a time partly overcome by the obvious and ordinary, though often unsatisfactory expedient of establishing agencies at points more or less distant. The difficulties were completely overcome through the adoption of a very simple plan to multiply insurances upon small risks near home.

The plan was to lend on first mortgages of newly constructed dwelling houses of moderate dimensions, in Philadelphia and the suburbs, enough money to pay the cost of the ground and the premium of a perpetual insurance on the buildings, with sometimes the addition of a small portion of the cost of their construction. The insurances were, of course, made by the Company's own policies. The two-fold purpose of a proper insurance, and a safe investment, was thus effected in every such case.

There was nothing novel in such transactions of combined investment and insurance. The novelty in this Company's transaction of such business was, that they were the first insurers who made it *systematic* instead of *occasional*. Every builder of limited means became aware that he could, with certainty, on making such an insurance with this Company, obtain the accommodation of such a loan upon mortgage, and that the time of credit, however limited in form, would, in fact, be indefinite, if the interest were punctually paid. The Company's business of this kind increased until such mortgage investments, I believe, 1100 or 1200 in number, of an average amount of less than $2,000, constituted four-fifths of the assets.

I have described this method of investment in order to introduce the statement of a wonderful truth. It is that, although this Company has paid, as I have said, five and a half millions for losses by fire, these losses have all, with one or two insignificant exceptions, occurred on property *not mortgaged* to the Company. The exceptions have been within a year or two, and of an amount so small as to be quite inappreciable. Thus, it may be said that these insurances and investments have actually been made *without any loss*. The Company, for several years past, might have annually divided more than 20 per cent. on their capital, though during the whole of this time, not a single new insurance had been effected. I do not mean that it would in that case, have been prudent for insurers to have done so. But the fact attests the safety of the business of an insurer who while extending it to the utmost fair limit, adheres to the cardinal maxim, already mentioned, of *never insuring where the interest of the insured might be promoted by carelessness* of the subject of insurance.

But who may be the cautious and energetic insurer capable of combining constant adherence to this maxim with a continual increase of business? Without answering the general question, let us consider Mr. Bancker's peculiar capacity for executing the two-fold function.

His perception was most acute, clear and comprehensive, his intellectual energy the most active, his decision was always prompt, and his purpose firm. I have already shown that the range of his practical experience was almost universal. Let me add here that no extent or magnitude of his operations ever prevented his vigilant, particular, and accurate attention to the minutest details of any and every business in which he was concerned for himself or others. This minute attention to the details of his duty was continued until the closing hour of his life.

As a man of general scientific tastes and attainments, he was known within these walls, and extensively beyond them. The general results of existing knowledge were, in the concrete, well understood by him; and he pursued experimental and analytical investigation sufficiently to enable him to understand the causes and modes of improvement, and to keep pace with its progress. His mind was thus amply stored with true knowledge. He was a constant, it might be said, universal reader. To the day of his death, he read as a student, not, according to the ordinary habit of old

age, as a critic or a censor. His own extensive library contained, in theology, in metaphysics, in history, belles lettres, natural philosophy, and every other department of useful knowledge, or polite accomplishment, all the literature of his varied and unremitting study. New books in every department, read by him, and on his parlor table upon their first publication, were, in due season, transferred to their proper shelves. His philosophical apparatus, constantly renewed from all parts of the world, was the collection of his long lifetime, and, like his library, was arranged according to the most improved plan. Possibly this apparatus may now, in some part, be antiquated. But I am informed that in certain departments, every modern improvement has been supplied, and that, under some heads, for example the polarization of light, the means and appliances for illustrative experiment are complete and unsurpassed.

He took pleasure in promoting and assisting the pursuit of useful knowledge by others. Such a man may, through such benevolence, contribute more to the diffusion of scientific information than those who justly obtain the praise of useful discoverers. Public lecturers on natural philosophy and on experimental chemistry, had always the free use of his apparatus. They frequently availed themselves of the privilege. I heard, in my childhood, public acknowledgments of his liberality in this respect; and they were, after the lapse of half a century, renewed in the hearing, perhaps, of others now present.

If I have described him rightly, it will be understood that he may have been eminently capable of comparing the results of investigations by other persons in different branches of art and science. This made his conversation often useful and instructive to practical men. Fallacious pretensions to originality of invention he detected at once, by intuition, as it were. He discerned, with as quick a glance, latent merit which was ultimately to succeed, not only in the practical, but likewise in the fine arts.

Stated Meeting, April 2, 1869.

Present, twenty-two members.

JOHN C. CRESSON, Vice-President, in the Chair.

A letter accepting membership was received from S. Nillson, dated Lund, Sweden, 3d Marz, 1869.

A letter was received from Mr. J. Whiteaves, Curator of the Museum of the Natural History Society at Montreal, dated March 29, 1869, acknowledging the receipt of Transactions

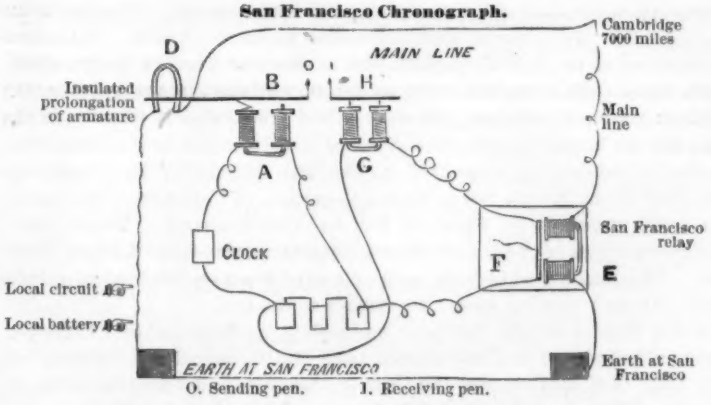
and Proceedings, and offering a set of the Canadian Naturalist in exchange.

A letter from the London Antiquarian Society, acknowledged the receipt of Proceedings, A. P. S., No. 80.

Donations for the Library were received from the London Geological Society, Essex Institute, Peabody Academy at Salem, New Bedford Library, George E. Ellis of Cambridge, New Jersey Historical Society, Franklin Institute, Academy of Natural Sciences, Philadelphia, and the Protestant Episcopal Church Hospital.

The decease of Dr. Robley Dunglison on the 1st inst., aged 71, at Philadelphia, was announced by Mr. Peale, and on motion of Mr. Fraley, Dr. Pancoast was appointed to prepare an obituary notice of the deceased.

Professor Trego communicated an extract from a letter from Mr. Davidson of the Coast Survey, to Mr. D. B. Smith of Germantown, detailing the method employed to obtain the recent determination of Longitude and the velocity of the electric current between Cambridge and San Francisco.



SAN FRANCISCO, *March 1st*, 1869.

I give you the first written news not only of our telegraph longitude success, but of the success of my plan for determining the *time of transmission of clock signals from my clock to Cambridge and back*, over 7,000 miles of wire, through 13 repeaters and a multitude of relays. Through the liberality of the Western Union Telegraph Company, I had two trans-continental lines placed at my use, and last night I succeeded

beautifully. My circuit was as follows. My clock breaks the local circuit every second, depriving the helix A of its electricity, and the magnet of its magnetism. This relieves the armature B, which is drawn away by a spring, and the pen C makes its record on the revolving cylinders of the chronograph. At the same instant the main current to Cambridge and back is broken by the insulated prolongation of the armature at D, and the break transmitted to Cambridge and back, through 7,000 miles of wire, to my relay E, which relieves the armature F, and the local circuit is broken; the helix G deprived of its electricity and the magnet of its magnetism, relieving the armature H, which is drawn away by a spring, and the pen I makes the record on the revolving cylinders of the chronograph. These two pens are on the same horizontal line. Our experiments show that it took 0.87 of a second to traverse the above circuit. I also made experiments through to Buffalo, Chicago, Omaha, Cheyenne, Salt Lake, and Virginia, and back. All successful. As this experiment was not contemplated by the programme of the longitude experiments, I have the satisfaction of seeing my ingenuity successfully proved.

Prof. Kirkwood communicated through Mr. Chase a discussion of the periodicity of the Sun's spots.

Mr. Chase made a communication of certain curious relationships of astronomical elements.

Mr. Dubois presented through Dr. Harris a specimen and analysis of silver ore.

Mr. Dubois offers the following recent notes from the Assay Office, U. S. Mint:

By far the largest single piece of silver ever brought to the Mint, was a cake or test-bottom, deposited on the 16th March, by Mr. Christian, President of the Brown Silver Mining Company, of Colorado. Its weight was 4,343 ounces troy, equal to 290 lbs. avoird. nearly. There was a small proportion of gold, and the net Mint value was 5,720 dollars, silver coin. This was stated to have been extracted from twenty tons of galena in the gangue; making about 286 dollars to the ton.

In the Report of the British Commission on International Coinage, lately published, we find an extract from the "Journal des Debats," of Nov. 13th, 1866, stating that the German assayers had found the average fineness of French gold coins of that year to be 898 thousandths, "and a fraction." It adds that this is an unworthy source of gain to Government, whose ambition it should be to have the coins *correct*.

The "Moniteur" of Nov. 20th (official organ), replies, that this is as near to standard as can be expected from the defects of practical operation; and that it is the duty of Government to prevent these "ill-founded criticisms."

Our own assays for many years, have proved a deficiency in the French coins, averaging about one thousandth.

The apology of the "Moniteur" has no just foundation. Both at this Mint, and at San Francisco, the gold coins are kept close to the mark, scarcely varying the tenth of a thousandth; as is proved by annual assays, and by foreign reports. British coinage is equally exact.

This fact affords an argument against the project of International Coinage. If we work to 900, and France to 899 or less, and both pass alike, the difference is against us.

We have a letter from a gentleman of South Carolina, an extract from which may lead to philosophical reflections, and therefore be in place:

"Our State, poor as it is, is full of coin. Planters will have nothing to do with securities. They can't spend money on negroes—they have land enough—and so they get gold, and bury it. I know of more than one who has over 30,000 dollars in gold, and of one who has 80,000 dollars.

"Even the 5 cent nickel is hoarded to an enormous extent. We have sent great quantities into the interior, but in travelling in the country you will never meet with them. I am told they are regarded as of full silver value."

Herewith is shown to the Society, a specimen of silver ore from the White Pine Region of Nevada, which is now drawing so much attention. This new mining district is in Lander county, in the mountain range, east of the Reese River district.

This specimen is from the "Black Spider Mine," and is a silicious gangue containing sulphides of copper and antimony, with rich seams of chloride of silver. It came marked "$10,000 per ton," and Mr. Eckfeldt's assay found it to contain half that proportion; or as we prefer to say in such cases, $2.50 per pound; inasmuch as such ores are not found by the ton; and it is desirable to avoid the grandiloquence which favors deception.

Mr. P. W. Sheafer communicated through the Secretary some boring records from the Anthracite Basins.

The Committee on the disposal of the Hall reported, and on motion of Dr. Le Conte, the subject was postponed.

The Publication Committee requested instructions as to the disposal of ninety pages of new matter, with several wood cuts and two more plates inserted by Prof. Cope in the memoir now going through the press, explaining that the original estimate of cost would probably cover the expense of the new matter. On motion of Dr. Le Conte the subject was referred to the original Committee.

Pending nominations, Nos. 622 to 626 were read.

And the Society was adjourned.

ON THE PERIODICITY OF THE SOLAR SPOTS.

By Daniel Kirkwood.

§ *I.—The Results of Observation.*

(1.) The most ancient observations of sun-spots, of which we have any record, are those of the Chinese in the year 321, A. D. The first notice of their detection by Europeans is found in the annals of the Frankish kings. A black spot, according to Adelmus, was seen on the sun's disk, March 17th, 807, and continued visible 8 days. Similar phenomena were again observed from the 28th of May to the 26th of August, A. D. 840. The year 1096 was also signalised by the appearance of spots so large as to be visible to the naked eye. The next date, in chronological order, is that of 1161, when a spot was seen by Averroës. Finally, on the 7th, 8th, and 16th of December, 1590, "a great blacke spot on the sunne," apparently "about the bignesse of a shilling," was observed at sea by those on board the ship "Richard of Arundell."* The foregoing are, we believe, the only undoubted instances in which these phenomena were observed previous to the invention of the telescope.

(2.) From 1610 to 1750 the sun was frequently observed through instruments of various optical power, and the sparseness, or even the entire absence of spots, during considerable intervals of time, as well as their great number and magnitude at other epochs, were noticed by different astronomers. From the latter date till the close of the first quarter of the present century the solar observations were more frequent and regular; still, no idea of the prevalence of *law* in the varying numbers and magnitudes of these mysterious objects had been even conjectured. We come now, however, to a most interesting and remarkable epoch in the history of solar physics.

(3.) *The 11-Year Period of Schwabe.*—In 1826, Hofrath Schwabe, of Dessau, commenced a series of sun-spot observations, which have been continued without interruption to the present time (1869). On each clear day he notes the number of visible groups, giving to each a special designation, to guard against counting it twice in a single rotation of the sun. In the first year, 1826, 118 spots were observed; the number was considerably greater in 1827; and in 1828 it had increased to 225. During the next five years there was a gradual *decrease;* the minimum being reached in 1833. The results of 43 years' observations are presented at one view in the following table:

* For authorities see Humboldt's Cosmos, Vol. IV., and Chambers' Descrip. Astronomy, p. 21.

TABLE I.

Schwabe's Observations of Solar Spots.

Year.	*Days of Obs.*	*Days of no Spots.*	*New Groups.*	*Max. and Min. according to Wolf.*
1826	277	22	118	
1827	273	2	161	
1828	282	0	225	Max. (1829.5)
1829	244	0	199	
1830	217	1	190	
1831	239	3	149	
1832	270	49	84	
1833	247	139	35	Min. (1833.8)
1834	273	120	51	
1835	244	18	173	
1836	200	0	272	
1837	168	0	333	Max. (1837.2)
1838	202	0	282	
1839	205	0	162	
1840	263	3	152	
1841	283	15	102	
1842	307	64	68	
1843	312	149	34	
1844	321	111	52	Min. (1844.0)
1845	332	29	114	
1846	314	1	157	
1847	276	0	257	
1848	278	0	330	Max. (1848.6)
1849	285	0	238	
1850	308	2	186	
1851	308	0	151	
1852	337	2	125	
1853	299	3	91	
1854	334	65	67	
1855	313	146	79	
1856	321	193	34	Min. (1856.2)
1857	324	52	98	
1858	335	0	188	
1859	343	0	205	
1860	332	0	211	Max. (1860.5)
1861	322	0	204	
1862	317	3	160	
1863	330	2	124	
1864	325	4	130	
1865	307	25	93	
1866	349	76	45	
1867	312	195	25	Min. (1867.0)
1868				

(4.) This table presents a very marked periodicity; the interval between two consecutive maxima or minima, being, according to Schwabe, about 10 years. Soon after the announcement of this interesting discovery Dr. Lamont, of Munich, detected a corresponding decennial period in the variation of the magnetic needle; the epochs of maxima and minima in the latter coinciding with those in the former. These results have also been confirmed by other observers in places quite remote from each other; so that the decennial *magnetic* cycle may be regarded as well established. The equality of this period with that of the solar spots naturally suggested the hypothesis of their intimate relationship. Such a causal connection may be difficult of explanation: the fact, however, is placed beyond doubt by the researches of Wolf and Sabine.* The former, besides carefully observing the sun-spots since

* These magnetic variations, which will not be discussed in the present paper, are mentioned to give completeness of view to the phenomena under consideration. It is also worthy of remark that the Aurora Borealis is believed to exhibit a corresponding periodicity.

1847, has discussed all accessible recorded observations, both solar and magnetic, bearing on the subject. He has thus ascertained a number of epochs of maxima and minima anterior to those observed by Schwabe,—from all of which he has determined the period of the spots to be 11.11 years. He undertakes to show, moreover, that this period coincides more exactly with that of the magnetic variation than the 10-year cycle of Lamont.

(5.) *The 56-Year Period.*—Besides Schwabe's period of 11 years, Wolf finds a larger cycle of 55 years, in which the solar activity passes through a series of changes. It is not, however, so distinctly marked as the cycle of Schwabe. Its last maximum was about 1837, and that preceding, about 1780. The *relative* number of spots in different years, from 1749 to 1826, when Schwabe commenced his systematic observations, are given (according to Wolf) in Table II.

TABLE II.

SOLAR SPOTS, FROM 1749 TO 1825.

Year.	*Rel. no. of Spots.*	*Max.*	*Min.*	*Year.*	*Rel. no. of Spots.*	*Max.*	*Min.*
1749	63.8			1788	90.6	1788.5	
1750	68.2	1750.0		1789	85.4.?)		
1751	40.9			1790	75.2		
1752	33.2			4791	46.1		
1753	23.1(?)			1792	52.7(?)		
1754	73.8			1793	20.7(?)		
1755	6.0		1755.7	1794	23.9		
1756	8.8			1795	16.5		
1757	30.4			1796	9.4		
1758	38.3(?)			1797	5.6		
1759	48.6(?)			1798	2.8		1798.5
1760	48.9			1799	5.9		
1761	75.0	1761.5		1800	16.1		
1762	50.6			1801	30.9(?)		
1763	37.4			1802	38.3(?)		
1764	34.5			1803	50.0(?)		
1765	23.0			1804	70.0(?)	1804.0	
1766	17.5(?)		1766.5	1805	50.0(?)		
1767	33.6			1806	30.0(?)		
1768	52.2			1807	10.0(?)		
1769	85.7			1808	2.2		
1770	79.4	1770.0		1809	0.8		
1771	73.2			1810	0.0		1810.5
1772	49.2			1811	0.9		
1773	39.8			1812	5.4		
1774	47.6(?)			1813	73.7		
1775	27.5		1775.8	1814	20.0(?)		
1776	35.2.?)			1815	35.0(?)		
1777	63.0			1816	45.5	1816.8	
1778	94.8			1817	43.5		
1779	99.2	1779.5		1818	34.1		
1780	72.6(?)			1819	22.5		
1781	67.7			1820	8.9		
1782	33.2(?)			1821	4.3		
1783	22.5(?)			1822	2.9		
1784	4.4(?)		1784.8	1823	1.3		1823.2
1785	18.3			1824	6.7		
1786	60.8			1825	17.4		
1787	92.8						

(6.) *The 233-Day Period.*—Prof. Wolf, after carefully discussing his own and Schwabe's observations, claims to have discovered two or three minor periods of solar activity. "By projecting all the results in a con-

tinuous curve, he finds in it a series of small undulations succeeding each other at an average interval of 7.65 months,"* or 233 days.

(7.) *The 27-Day Period.*—The same astronomer thinks he has detected a short period of variation corresponding to the sun's time of rotation with respect to the earth, or about 27 days.

(8.) *The 584-Day Period.*—De La Rue, Stewart and Lœwy, have found a period varying between 18 and 20 months; the mean being about 584 days.† Other periods of maxima and minima will probably be detected; but those we have enumerated are perhaps the only ones sufficiently well established to justify any attempt at explanation.

§ II.—*Discussion of the Phenomena.*

(9.) That the solar spots are produced in some way by the planetary disturbance of the photosphere, is now generally admitted. As yet, however, the manner in which this influence is exerted, can be little more than matter of conjecture. If the action is analogous to that of the moon on the earth, the relative disturbing power of the different members of the system will be as follows:

TABLE III.

RELATIVE INFLUENCE OF THE PLANETS ON THE SUN'S SURFACE.

Name.	*Mass.*	*In Aph.*	*At M. Dist.*	*In Perih.*
Mercury	$\frac{1}{4865751}$ (Encke)	63	111	219
	$\frac{1}{3000000}$ (Leverrier)	102	180	355
Venus	$\frac{1}{401211}$	203	207	211
Earth	$\frac{1}{314756}$	95	100	105
Mars	$\frac{1}{2894790}$	2	3	4
Jupiter	$\frac{1}{1047}$	194	214	236
Saturn	$\frac{1}{3498}$	8	10	12
Uranus	$\frac{1}{24198}$	0	0	0
Neptune	$\frac{1}{19780}$	0	0	0

This table is derived from the formula

$$\delta = \frac{m}{a^3},$$

where δ represents the disturbing power of a planet, m, its mass, and a, its distance.

(10.) The connection between the number of sun-spots and the positions of the planets was noticed by Wolf as long since as 1858. In the *Comptes Rendus*, for January, 1859, he published a formula in which the number of sun-spots was made to depend on the different configurations of Venus, the Earth, Jupiter and Saturn. In the learned and interesting memoir—previously referred to—of De La Rue, Stewart and Lœwy, the causal connection between the positions of Venus and Jupiter and the behaviour of sun-spots seems to be clearly established. Professor Wil-

* Sir John Herschel, Quart. Jour. Sci., Vol. I., p. 228, April, 1864.
† Am. Journ. of Sci. and Arts, for March, 1867.

liam A. Norton, of Yale College, in his "Treatise on Astronomy," pp. 434—436, presents a brief but valuable discussion of the same subject. An inspection, however, of Table III., shows that writers generally have given undue weight to Saturn's influence. Again, although Mercury's action at aphelion is but feeble, and even at his mean distance, less than that of Venus or Jupiter, his perturbing power at *perihelion* is the greatest of all planets—a fact which certainly demands consideration in any theory which refers the origin of solar spots to planetary agency. In short, after giving the subject much study and attention, I deem it impossible, with the numbers given in table III., *and without the introduction of any modifying cause*, to establish a general correspondence between the different sun-spot periods and those of regularly recurring planetary configurations.

(11.) But the hypothesis that a particular portion of the sun's surface is more favorable to spot formation—or, in other words, more susceptible to planetary influence—than others, will, it is believed, obviate all difficulty. Is there, then, any independent probability of the truth of this hypothesis? It is well known that the formation of spots occurs chiefly between particular parallels of *latitude*, and that the numbers are greater in the northern than in the southern hemisphere. It seems, therefore, at least not improbable that a like difference may exist in regard to *longitude*. "Sömmering directs attention to the fact, that there are certain meridian belts on the sun's disk, in which he had never observed a solar-spot for many years together."* Buys-Ballot, of Utrecht, has found, from an elaborate discussion of a great number of meteorological observations, that there is a short period of variation in the amount of solar heat received by our planet; the period from maximum to maximum coinciding, at least approximately, with that of the sun's rotation with respect to the earth. Sir William Herschel also believed that one side of the sun, on account of some peculiarity in its physical constitution, was less adapted to radiate light and heat than the other.

(12.) On the hypothesis which we have ventured to suggest, the sun-spot period would be equal to the interval between two conjunctions of the disturbing planets on the heliographic meridian (designated by M) of that part of the surface most susceptible to their influence. It would depend, therefore, on the ratio of the sun's period of rotation to the interval between two consecutive conjunctions of such planets. Or, as Mercury's influence is extremely variable, a maximum would be produced by this planet's perihelion passage, when the most susceptible part of the sun's surface had the same, or nearly the same, heliocentric longitude. In order, then, to test this hypothesis, we must first inquire what is the most probable period of the sun's rotation?

(13.) On account of the *proper* motion of the solar spots, the time of the sun's rotation as determined by their *apparent* motion across the disk, varies from about 25 to 29 days. The *proper* motion of the spots

* Humboldt's Cosmos, Vol. IV., p. 378.

has recently been discussed with great labor and ability by Professor Spöerer, of Anclam, and Mr. Carrington, of England, who have shown conclusively that the rapidity of movement varies regularly with the latitude. The equatorial portions have the greatest angular velocity; in other words, the proper motion of the spots is in a direction contrary to that of the sun's rotation. The formula by which the astronomers named express the law for the dependence of the sun's apparent period of rotation on the latitude are as follows:

According to Carrington, $\xi = 865' - 165' \sin \frac{7}{4} l$ . . . . (1)

" " Spöerer, $\xi = 16.°8475 - 3°.3812 \sin (41°13' + l,)$. (2)

where ξ is the arc described in a solar day. The true time of rotation is supposed to be that indicated by an equatorial spot; and on this assumption, (1) gives

$P = 24.^d9711 = 24^d\ 23^h\ 18^m\ 23^s$ . . . . . (3)

or, (2) gives

$P = 24.^d62447 = 24^d\ 14^h\ 59^m\ 0^s$ . . . . . (4)

The true value is probably between the results here given.

(14.) But will this modifying element in the theory of planetary action afford a satisfactory explanation of the periodic recurrence of maxima and minima of solar spots? Let us consider.

(*a.*) *The 11-Year Cycle.*—The anomalistic period of Mercury is $87.^d9702$, and

$87.^d9702 \times 46 = 4046.^d6292 = 11.^y077 = T_1$ . . . . . (5)

This is very nearly equal to Wolf's value of the cycle, and agrees at least equally well with recorded facts.* Again,

$$\frac{T_1}{163} = 24.^d82594 = 24^d\ 19^h\ 49^m\ 21^s \quad . \quad . \quad . \quad . \quad . \quad (6)$$

which is nearly a mean between Spöerer's and Carrington's values of the sun's period of rotation. With this, therefore, as the time of the sun's axial revolution, we have 46 times the period of Mercury—equal to 163 times that of the sun's rotation. The recurrence of maxima at mean intervals of 11.077 years would thus be accounted for.† Again, the epochs at which sun-spots were seen before the invention of the telescope may be presumed, with much probability, to have been nearly co-incident with the maxima epochs of Schwabe's cycle. Now, it is a remarkable

* The following astronomical cycles are also nearly equal to this period of variation:

1. 18 periods of Venus=11.074*y*.	4. $17t_1$=11.030*y*
2. 35 syn. per. of Mer.=11.104	5. $28t_2$=11.082
3. 1 period of Jupiter.=11.860	6. $45t_3$=11.063,

where t_1=the syn. per. of Venus with respect to Jupiter; t_2=syn. per. of Mercury with respect to Venus; and t_3=that of Mercury with respect to Jupiter.

† It is not probable that Mercury is on the meridian M precisely at the epoch of perihelion passage. It is only necessary to suppose this coincidence to occur when the planet is *near* the perihelion point. Even at the distance of 20° the diminution of the disturbing power would be extremely small.

fact that all of those dates given in Art. (1), except perhaps the last, harmonise with the value which we have adopted for Schwabe's period of variation. Thus,

From	321, A.D.	to	1860,	we have	139	periods of	11.072+years each.
"	321	to	807	"	44	"	11.045 "
"	807.22	to	840.5	"	3	"	11.093 "
"	840.5	to	1096	"	23	"	11.109 "
"	1096	to	1161	"	6	"	10.833 "
"	1161	to	1590.9	"	39	"	11.024 "
"	1590.9	to	1750.0	"	14	"	11.367(?) "
"	1750.0	to	1829.0	"	7	"	11.286 "
"	1829.0	to	1860.5	"	3	"	10.500 "

The variability of the period will be hereafter considered.

(*b.*) *Wolf's Cycle of* 56–57 *Years.*—The synodic revolution of Mercury is $115^{d}87748$, and

$$115.^{d}87748 \times 177 = 20510.^{d}31396 = 56.^{y}15324 = T_2 \quad . \quad . \quad (7)$$

In this period the line of conjunction of Mercury and the earth advances 56.15324 revolutions. Now,

$$\frac{T_2}{826.15324} = 24.^{d}82628 = 24^{d}\ 19^{h}\ 49^{m}\ 50^{s} \quad . \quad . \quad . \quad . \quad (8)$$

This value of the sun's period of rotation differs from that in (6) by only 29 seconds. Adopting it, therefore, we find that Mercury and the earth will be in conjunction on the same heliographic meridian at regularly recurring epochs of 56 years and 56 days.

(*c.*) *The* 233*-Day Period.*—The mean interval between the consecutive conjunctions of Venus and Jupiter is $236^{d}992$. The close agreement of these periods, leaves little room to doubt that the latter is the true period of spot variation.

(*d.*) *The* 27*-Day Period.*—This is at once satisfactorily accounted for on the hypothesis prepared in Art (11).

(*e.*) *The* 584*-Day Period.*—The identity of this period with that of the synodic revolution of Venus has already been indicated by De La Rue, Stewart and Lœwy.

(15.) It would be easy to point out theoretically other periods of variation, which an exact discussion of observations would probably confirm. It will be obvious, however, that the actual phenomena must be exceedingly complicated. The great eccentricity of Mercury's orbit; the ever-varying configurations of the disturbing planets; the probably unequal susceptibility of different parts of the sun's surface to their influence; combined, perhaps, with other causes, but imperfectly understood, must render the complete discussion of the phenomena both operose and difficult. The subject, in short, presents a new and interesting department of the theory of perturbations.

(16.) A careful inspection of tables I. and II. will indicate that Schwabe's cycle is liable to considerable variation, both in duration and intensity. The epochs of greatest disturbance were 1837 and 1848, when the number of spots was about 50 per cent. greater than in 1828 and 1860.

The observations of recent years seem to render it probable, moreover, that the epoch of extraordinary activity is passing away. The number of new groups in 1867 was less than in any other year since the commencement of Schwabe's observations; while the whole number counted during the 11 years from 1857 to 1867 inclusive, as compared with that of the 11 years immediately preceding, was as 1483 to 1715.

(17.) *The Great Irregularity of the* 11-*Year Cycle from* 1828 *to* 1860.—Mercury was in perihelion about 1838.277, and this was probably the maximum epoch *depending on Mercury alone.* But the *observed* epoch of greatest disturbance was about 1837.2. Let us, then, inquire whether any configuration of the disturbing planets will account for this marked deviation from regularity.

Mercury and Venus had the same mean longitude (343°) near the 1st of April, 1837, or, about 1837.247*, when Mercury was at less than its mean distance from the sun. If this conjunction occurred on, or very near, the solar meridian M, an extraordinary disturbance of the photosphere would evidently result. Now, the interval from 1837.247 to 1838.277 was 376.^{d}2075, during which time the sun would have performed 15 *entire* rotations; also the arc between longitude 343° and 75°, (that of Mercury's perihelion,) is 92°. The daily motion of Mercury, moreover, when nearest the sun is about 5°. If, then, the conjunction of 1837.247 occurred over the solar meridian M, and if we represent by t the number of days from 1838.277 till Mercury was on the same solar meridian, we shall have, taking the sun's period of rotation as adopted in (6)

$$\frac{376.2075 + t}{15 + \frac{92 \times 5\,t}{360}} = 24.826 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

whence $t = 3.^{d}8 +$, and $5° \times t = 19° + \quad . \quad . \quad . \quad . \quad . \quad (10)$

Hence the longitude of Mercury when on the solar meridian M in 1838, and at other recent maximum epochs, was 94°, or 19° from the perihelion. Again, the interval between two consecutive conjunctions of Mercury and Venus is 144^{d}.5651, and

$$144.^{d}5651 \times 28 = 4047.^{d}8228,$$

exceeding the period of 163 solar rotations by 1.^{d}19. It is easy to see, therefore, that when the mean longitudes of the planets were the same (about 348°) in 1848.328, the ecliptical longitude of the solar meridian M was 12° in advance, and that the disturbing effect would consequently be diminished, although still sufficient to fix the maximum in 1848 instead of 1849. In like manner the further decrease of solar activity in 1859—60, as well as the observed increase from 1828 to 1837, is readily accounted for.

(18.) Mercury and the earth had the same mean longitude, 0°, ± about 1837.726.

Mercury and Venus, " " 343° ± " 1837.247.

* This is not the precise epoch of conjunction; we may adopt it, however, without material error. It may be remarked that a great disturbance of the photosphere would also be produced by the passage of the planets *successively* over the meridian M, shortly *before* the time of actual conjunction.

The interval between these epochs was 174.^{d}95. Hence if these conjunctions occurred on the solar meridian M, the sun, during the interval, must have performed 7.047 revolutions. Now,

$$\frac{174.^{d}95}{7.047} = 24.^{d}826,$$

the same value of the sun's period of rotation as was found in (6). The harmony of these results affords a striking confirmation of the proposed hypothesis.

(19.) We have given a very imperfect discussion of the spot-cycles due to the disturbing effect of Mercury, Venus, and the earth. These results must be materially modified by Jupiter, whose disturbing influence has not yet been considered. It is not too much to hope that by means of a more exact analysis, in which the action of each of the planets, Mercury, Venus, the earth, and Jupiter shall be taken into account, the condition of the sun's surface may be predicted with as much certainty as the ebbing and flowing of the tides at any particular locality on the surface of our planet.

(20.) An easy calculation will show that the greatest tide produced in the sun's photosphere by any single planet must be less than an inch in height. The actual disturbance, therefore, is certainly much greater than might reasonably have been expected from a cause apparently so insignificant. It is conceivable, however, that the physical constitution of the fluids forming the luminous surface may be such that a very slight impulse may be sufficient to create a rupture, and thus occasion the phenomena observed.

(21.) The foregoing discussion justifies, we think, the following conclusions:

1. A connection between the behaviour of sun-spots and the configurations of certain planets has been placed beyond reasonable doubt.

2. The theory, however, of spot formation by planetary influence is encumbered with anomalies and even inconsistencies, unless we admit the co-operation of a modifying cause.

3. The hypothesis that a particular part of the solar surface is more susceptible than others to planetary disturbance is rendered probable by the observations of different astronomers.

4. The 11-year cycle of spot-variation is mainly dependent on the influence of Mercury.

5. The marked irregularity of this period from 1822 to 1867, is in a great measure due to the disturbing action of Venus.

6. Wolf's 56-year cycle is determined by the joint action of Mercury and the earth. And,

Finally, *the hypothesis proposed accounts, as we have seen, for all the well defined cycles of spot-variations.*

Bloomington, Indiana, *March 15th*, 1869.

COSMICAL RELATIONS OF LIGHT TO GRAVITY.

By Pliny Earle Chase.

Prof. Kirkwood's very interesting presentation of the evidence which indicates special lines of disturbance on the Sun's surface, furnishes a new analogy to guide the researches of investigators. The well known dependence of one class of magnetic fluctuations on the position of ocean meridians, strengthens his hypothesis of similar meridians beneath the solar photosphere* which may possibly be detected by spectroscopic observations, while the coincidence of luminous, magnetic, and gravitating lines encourages renewed efforts to trace out the fundamental harmonies of our planetary system.

Wheatstone's experiments have been generally regarded as proving that the velocity of electricity is greater than that of light. But the outbreak of the solar spot recorded by Sir John Herschel, and the simultaneous agitation of the magnetic needles at Kew and elsewhere, render it probable that electrical action is sometimes, if not always, transmitted with precisely the same velocity as light. May it not be that the induction between the successive coils of a wire, however widely they may be separated, produces a spark before the electric current has traversed the whole extent of the wire? Or, if the wire were transparent, is there any reason for supposing that it would transmit a wave of light less rapidly than one of electricity?

The analogies to which attention has been called by numerous observers, between phenomena which are dependent upon various forms of force, may be supplemented by relations, no less curious and interesting, of light to cosmical gravitation, some of which are shown in the following equations. They appear to open a new field for inquiry, in which analysts may, perhaps, find profitable employment.

Let the sun and planets be denoted by the following subscript figures. $\odot_1$; $☿_2$; $♀_3$; $\oplus_4$; $♂_5$; inner asteroid$_6$; mean asteroid$_7$; superior asteroid$_8$; $♃_9$; $♄_{10}$; $♅_{11}$; $♆_{12}$.

Let h be the modulus of solar light, on the hypothesis that the luminiferous æther is an indefinitely elastic, material medium, and that, therefore, $h = \frac{u^2}{2g_1}$, u denoting the velocity of light.

V = velocity, and T = time of theoretical planetary revolution at the surface of the sun, or of a planet.

v_n = velocity, and t_n = time, of axial rotation of n

r = radius

m = mass

d = mean distance from sun

γ = centre of gyration = $r\sqrt{\frac{2}{5}}$

* See also Henshall on $♂$ of $☿$, $♀$, and $♃$ with same face of sun. *Cosmos*, xvii., Nov. 1860. p. 573.

e = 1 + orbital excentricity

i = *effective* inertia of votation = moment of inertia divided by time of revolution = $m\sqrt{d}$ Then

1. $t_1 = \frac{2h}{u} = \left(\frac{2h}{g_1}\right)^{\frac{1}{2}}$ $\therefore g_1 t_1 = u$, and $v = 2g_1 \frac{\pi r_1}{u} = \frac{1}{4} \cdot \frac{2g_1}{u} \cdot \frac{surface}{r}$
2. $\frac{d_7}{r_1} = \left(\frac{h}{r_1}\right)^{\frac{1}{2}} = \frac{i}{m}$ of æther
3. $\frac{d_{12}}{d_2} = \left(\frac{h}{r_1}\right)^{\frac{1}{2}}$
4. $d_4 = \frac{d_7}{\pi}$
5. $\frac{d_4}{\pi r_1} = \left(\frac{m_1}{m_4}\right)^{\frac{1}{2}}$
6. $d_4 = \left(\frac{\gamma}{e_4}\right)^2 d_4$
7. $d_3 = \frac{3\gamma}{e_4} d_2$
8. $d_5 = 2\,(d_4 - \gamma d_4)$
9. $\frac{d_9}{r_1} = \frac{m_1 \times e_9}{m_9}$
10. $d_{10} = \frac{d_{12}}{\pi}$
11. $\sqrt{2}\, d_6 = d_7$
12. $\gamma\, d_6 = d_6$
13. $\frac{d_{12} \times d_{11}}{d_4 \times r_1} = \left(\frac{m_1}{m_4}\right)^{\frac{1}{2}}$
14. $d_i\,(_{2,\,3,\,4,\,5,}) = 2\gamma\, d_2$
15. $\frac{V_1}{v_1} = \frac{d_4}{r_1}$
16. $\frac{V_4}{v_4} = \frac{d_9 \times e_9}{r_4} \times \pi$

The motion of the air in the earth's annual revolution and daily rotation, is slightly undulatory, but hardly perceptibly differing from a regular ellipse. Its motions are controlled, mainly by solar, and subordinately by terrestrial force, the former giving a motion of 63.8, and a moment of inertia of 543,000,000 times the latter. According to Marriotte's law, the specific gravity of the atmosphere should be determined by the conjoined pressure of solar and terrestrial gravity. The liquid and solid portions of the earth, however, are not subject to Marriotte's Law.

In any fluid which is simultaneously affected by two attracting masses, e. g: by the earth and the sun, it would seem that two systems of waves should be generated, moving with velocities v, v^1 such that $v = \sqrt{2gh}$ $v^1 = \sqrt{2g^1h^1}$

But if the fluid is on the earth's surface, $h = h^1$, while at the centres of force, $g : g^1 :: m : m^1$.

In the orbital motion the pressure of solar force is nearly constant, but terrestrial gravity tends to maintain the atmosphere at a uniform level, or in a constant volume. Now the kinetic energy under constant pressure : that under constant volume : : 1.421 : 1, or very nearly : : $\sqrt{2}$: 1.

M. Trèves found that the number of oscillations in a tuning fork was increased $\frac{1}{317}$ by magnetizing the fork. Farther experiments are desirable to determine whether his result may be accepted as a general one, but it may be temporarily regarded as curiously coincident with our hypothetical case in which

17. $v : v^1 : : \sqrt{2m} : \sqrt{m^1}$
$817 : 1 : : \sqrt{2m_1} : \sqrt{m_4}$

18. $\sqrt{2m_1} : \sqrt{m_4} : :$ sp. gr. water : sp. gr. air (at mean temperature)

19. $\left(2m_1\right)^{\frac{1}{4}} : \left(m_4\right)^{\frac{1}{4}} : g_1 : g_4$

20. $2\, g_4\, t_4 \times \frac{g_4}{g_1} = \mathrm{V}_4$

21. The inertia of the air which is retarded by the thermal and tidal "brakes" appears to be overcome and the wave-equilibrium restored, after g_4 has acted for a sufficient time to give V_4.

22. $d_4 = \left(\frac{\text{yearly}}{\text{daily}} \text{ barometric range}\right)^2$ at St. Helena $\times\ g_4\, t_4{}^2$

23. $2\sqrt{2m_1} \times (e_4)^2 : \sqrt{m_4} : : g_4 : g_1 \times \left(\frac{r_1}{d_4}\right)^2$

24. Mean vel. of sound = mean vel. of air.

25. If $\frac{d_9}{r_1}$ be divided in proportion to the i of the several planets, Jupiter's proportion will be $\frac{8}{113}$ of 1125.84 = 692.83, and $692.83 \times \mathrm{V}_1 = u$.

It may be desirable to modify some of these equations by considerations connected with centrifugal force. The closeness of the principal analogies may be illustrated by a few examples, in which I assume the following values as a basis of comparison : $\lambda \frac{g_1}{g_4} = 1.449662$; $\lambda\, r_1 = 5.630334$ $\therefore\ \lambda\, h = 11.302517$;—and Newcomb's estimates, $\frac{m_1}{m_4} = 326{,}800$; $d_4 = 92{,}380{,}000$; $u = 185{,}600$.

	Spörer.	Faye.	Carrington.	Kirkwood.	Theory.	Mean.
1.	$t_1 = 24.62447$ dy.	25.07472 dy.	24.9711 dy.	24.82594 dy	25.0297 dy.	24.9052 dy.
	$\therefore u = 188{,}697$ m.	185,267 m.	186,035 m.	187.123 m.	185,600 m.	186,528 m.

		Theoretical.	Assumed.
3.	$\frac{d_{12}}{d_2} = \frac{30.070552}{\cdot 3870984}$	$\therefore \frac{h}{r_1} = 468{,}770$	465,604.
4.	$\frac{d_7}{r_1} = 682.3516$	$\therefore \frac{d_7}{d_4} = 3.1416$	3.153.

5. $\frac{d_4}{\pi r_4} = 68.88$ $\therefore \frac{m_1}{m_4} = 326,800$ [327,280]*

10. $\frac{d_{12}}{d_{10}} = \frac{30.070552}{9.5388}$ $\therefore \frac{d_{12}}{d_{10}} = 3,1416$ 3,1524.

15. $\frac{d_4}{r_1} = 216.395$ $\therefore \frac{V_1}{v_1} = 216,395$ 218,142.

17. $\frac{v}{v^1} = 817$ $\therefore \frac{m_1}{m_4} = 333,750$ 326,800.

18. Mean s. g. $\frac{\text{water}}{\text{air}} = 807.45$† $\therefore \frac{m_1}{m_4}$ 325,380 326,800.

19. $(2 \times 326,800)^{\frac{1}{4}} = 28.4\dot{3}$ $\therefore \frac{g_1}{g_4} = 28.4\dot{3}$ 28.162.

20. $2g_4 t_4 \times \frac{g_4}{g_1} = 18.7$ m. $\therefore V_4 = 18.7$ 18.4.

21. $2g_4 \times 50\frac{1}{4} \times 60 = 18.376$ m. $\therefore V_4 = 18.376$ 18.4.

22. $\left(\frac{.135}{.067}\right)^2 \times g_4 t_4^{\ 2} = 92,361,900$ m. $\therefore d_4 = 92,361,900$ 92,380,000.

24. $\frac{\text{cos. } 43° \times 2\pi r_4}{t_4} = 1112.97$ ft. $\therefore$ vel. $= 1112.97$ 1118.09‡

25. 692.83 $V_1 = 187,750$ m. $\therefore u = 187,750$ 185,600.

26. The earth's proportion would be .000862 of 1125.84 = .97, and

$$.97 \times \frac{V_1}{v_1} = \frac{4\pi}{3} \times \frac{\text{mass of sun}}{\text{mass of planets}}$$

27. $.97 \times 2\, g_4\, T_4 = u$.

The following estimates of the sun's mass and distance, and the velocity of light, are derived from the foregoing equations :

	From magnetic acceleration.	From sp. gravity of air.	From length of day.	From atmospheric inertia.	From annual barometric range.	From inertia of Jupiter.	From mean estimate of g_1‖
Sun's mass	333,750	325,380	341,560	325,520	326,610	338,490	321,940
Sun's distance	93,033,200	92,246,000	93,886,300	92,260,000	92,361,900	93,450,000	91,920,000
Vel. of light	186,910	185,330	188,630	185,360	185,560	187,750	184,670

The study of gaseous molecular motions may, perhaps, be aided by the analogies of luminous vibrations. The equation $u = g_1 t_1$ seems to be an important one. A solitary planet or particle would acquire the velocity of revolution in a circular orbit in $\frac{1}{6}$ of the time of *revolution*, but the particles of the hypothetical elastic fluid to which the luminous vibrations are attributed, under the combined pressure of g_1 and of their own adja-

* As the value assumed for r_1 was derived from this equation, the theoretical and assumed results of course correspond exactly. The bracketed number corresponds to the ordinary value $\frac{d_4}{r_1} = 216.4$. The estimates vary from 214.9 to 217.5.

† According to Johnston's Physical Atlas, the average of the air and ocean temperatures on the parallels of 45° latitude, is 53°.69 F. The specific gravity of air at that temperature is 1 ÷ 807.45.

‡ The retardations of the atmospheric tides at St. Helena, at 0^h, 6^h, 12^h, and 18^h respectively, are 59^m, 85^m, 26^m and 31^m, the mean retardation being $50\frac{1}{4}^m$ [*See Trans. A. P. S.*, vol. 13, p. 128.]

‖ Mean of polar (32°) and equatorial (82°) = 57°. Isothermal of 57° = latitude 43°.

cent particles, do not acquire the oscillatory velocity of light until g_1 has acted for $\frac{1}{2}$ the time of *rotation*. Does this indicate successive vibrations in the directions of three co-ordinate axes? And does the tidal action of the planets contribute to the disturbance from which the vibrations originate? The sun-spot theory, and equations 25, 26, and 27, favor such a hypothesis. The proportionality indicated by (1,)

$$u : v_1 : : g_1 t_1^2 : 2 \pi r_1$$

becomes significant, if we consider that any equatorial particle must move through the distance $2 \pi r_1$ before it returns to the same relative position, and that during the entire series of disturbances, through which it passes in the interval, g_1 is exerting an energy, the resultant of which is equivalent to a fall of $g_1 t_1^2$.

BORING RECORDS FROM THE ANTHRACITE BASIN.

By Mr. P. W. Sheafer.

Record of Lower Boring.	*Nassau Shaft.*	*One mile north of Scranton.*	
From Surface below R. Road.	8′ 3″		
Rock,	3′ 0″		11′ 3″
Coal,			1′ 0″
Rock,	1′ 2″		
Sandy Gravel,	4′ 7″		
Slate,	6″		
Rock,	1′ 2″		
Slate,	20′ 3″		
Sand Stone,	8′ 4″		
Light Slate,	4′ 6″		
Dark Slate,	4″		39′ 10″
Coal,			2′ 6″
Dark Slate,	7′ 4″		
Hard Rock,	6″		
Dark Slate,	2′ 1″		9′ 11″
Coal,		3′ 0″	
Slate,		3″	
Coal,		1′ 0″	4′ 3″
Slate,	2′ 1″		
Slate, (hard bands,)	1′ 11″		
Hard Rock,	3′ 6″		
Slate, (hard bands,)	20′ 8″		
Dark Hard Rock,	7′ 1″		
Dark Slate,	10′ 6″		44′ 9″
Coal, pure,		8′ 4″	
Coal, bony,		3″	
Coal, good,		6″	
Coal, bony,		6″	
Coal, good,		11″	10′ 6″
Hard Rock,	1′ 4″		
			128′ 7″

The above is from the journal kept by Wm. Barryman, reported to Mr. P. W. Sheafer, Eng. Mines, Pottsville, in 1857. Rocks dip gently South.

Record of Upper Boring.	*Nassau Coal Company. Scranton, Pa.*		*One mile north of*
From surface,	13′ 00″		
Rock,	12′ 7″		26′ 27″
Coal mixed with Slate,			2′ 0″
Light Rock,	21′ 3″		
Dark Sand,	6″		
Hard Rock,	14′ 1″		35′ 10″
Coal,			1′ 00″
Slate, dark soft,	1′ 0″		
Slate, dark,	1′ 4″		
Rock, light,	12′ 4″		
Slate, dark,	4′ 0″		18′ 6″
Coal,		9″	
Black Slate,		2′ 0″	
Coal (with Slate,)		9″	
Coal, pure,		5′ 6″	9′ 0″
Slate, dark, hard,	10′ 0″		
Rock,	9′ 9″		
Slate,	11′ 0″		30′ 9″
Coal,			1′ 9″
Slate, (hard bands,)	5′ 3″		
Rock,	1′ 0″		
Slate, (hard bands,)	6′ 8″		12′ 11″
Coal,			2′ 8″
Slate, dark hard,	12′ 9″		
Rock, light,	5′ 3″		
Slate, (hard bands,)	3′ 0″		
Rock, hard,	1′ 3″		
Slate bands,	4′ 3″		
Slate and hard bands,	18′ 10″		
Slate, dark,	8′ 7″		
Rock, hard,	3′ 0″		
Rock, light,	9′ 6″		
Slate, dark,	9″		66′ 4″
Coal, pure,			8′ 0″
Slate, dark,	5′ 6″		
Slate, hard, light,	1′ 1″		
Rock, hard,	8″		
Rock, hard, light,	17′ 3″		
Slate, dark,	1′ 0″		25′ 6″
Coal,			3′ 6″
Slate, dark,	1′ 0″		
Slate, light,	6′ 5″		7′ 5″

Coal,			1′ 6″	
Slate, light,			3″	
Coal,			1′ 0″	2′ 9″
Slate, black,	6′ 11″			
Slate, (hard bands,)	8′ 7″			
Slate, dark,	2′ 5″			
Rock, light,	5′ 1″			
Slate, dark,	8′ 8″			
Slate, light,	8′ 6″			
Rock, light,	1′ 0″			
Slate, black,	3′ 11″			
Rock, hard,	7″			
Slate, black,	1′ 8″			47′ 4″
Coal,				10′ 8″
Slate,	6″			
Rock, hard,	10″	(measured on rods)		309′ 3½

NOTE. Journal kept by Mr. Berryman, and reported to Mr. P. W. Sheafer, in 1857.

Swartz Boring above Dunmore, about N. 78° ¾E. (7,000 feet) from the corners, in Dunmore, near Scranton. By Mr. Stevenson, Jan. 6, 1857, to P. W. Sheafer.

Earth from Surface down,	2′ 0″		
Sand Rock, hard, coarse,	28′ 0″		
Sand Rock, yellow,	18′ 0″		49′ 0″
Coal,			5′ 0″
Sand Rock and Slates,	28′ 0″		
Blue Rock, hard,	11′ 0″		
Slate,	3′ 6″		42′ 6″
Coal,			4′ 2″
Slate,	3′ 6″		
Sand Rock,	19′ 0″		
Blue Rock, hard,	35′ 0″		
Slate,	5′ 0″		62′ 6″
Coal,			4′ 6″
Slate,	21′ 0″		
Blue Rock, hard	2′ 0″		190′ 8″

National Anthracite Company's Cross Section.

Top Rock.					
Slate,	8″				
Bony Coal,	2′ 0″				
Top Bench of worked Coal,			5′ 6″		
Middle Bench of Coal,			10″		11′ 10″
Bottom Bench of Coal,	1′ 6″	to	2′ 0″		
Bony Coal, rough,	2′ 0″				
Slate,	19′ 0″				

Tolerably Good Top Slate,			
Top Bench of good Coal,		4′ 10″	}
Slate,	6″		} 6′ 1½″
Bottom Bench of Rough Coal,		9½″	}

The above is a section of the two beds of Coal in the Lackawanna Coal Basin, 1½ miles west from Scranton, furnished by the boss miner to P. W. Sheafer, March 11, 1857. Opened by two drifts on the South bank of the Lackawanna, where the Coal dips about 5° West.

These Coal were known as the 9 and 11 foot beds.

Stated Meeting, April 16, 1869.

Present, seventeen members.

Dr. GEORGE B. WOOD, President, in the Chair.

A letter accepting membership was received from J. C. Mill, dated Blackheath Park, March 22, 1869.

Letters acknowledging the receipt of diplomas of membership were received from John Tyndall, dated London, March 20th, and from H. A. Newton, dated Yale College, March 2d, 1869.

Donations for the Library were received from the Royal Academy and Observatory at Turin, the Geological Society and M. Bossange at Paris, the R. Astronomical Society and Mr. Quaritch at London, the Royal Society at Edinburgh, the Portland Society of Natural History, the Rev. J. B. Perry, the Essex Institute and Cambridge Museum, the editors of the Journal of Medical Sciences, Dr. Isaac Lea, J. B. Lippincott & Co., and the Fairmount Park Commissioners of Philadelphia.

Professor Spencer F. Baird, of Washington, was appointed to prepare an obituary notice of the late member, John Cassin, of Philadelphia.

The Committee to which was referred additions to the Memoir of Professor Cope, reported in favor of publication.

Professor Cresson introduced the subject of the brilliant Aurora Borealis of the preceding evening, which Dr. Emerson, Mr. Price, and Mr. Chase described as seen by them.

Mr. Lesley said that it was so brilliant and roseate at Washington, D. C., that the fire engines were taken out; that it did not invade the southern half of the heavens to any extent; but that he observed a brightly illuminated feather, 30° or 40° in length from east to west, float slowly west-north-westward, some little distance south of the zenith, gradually expanding its dimensions but scarcely changing its form, during half an hour. Its head or eastern point was, when first seen, say 40° east of the meridian, and at the end of half an hour, quite that distance west of the meridian. It was evidently an electrified cirrus cloud, and could no doubt have been watched until it sank to the horizon, but for the fact that it passed lengthwise directly under the moon, then about four days old, and very bright. Castor and Pollux shone brightly through it, as it passed beneath them. At one time an auroral feather shot from its northern edge and streamed along, westward, nearly parallel with its northern edge, continuing brilliant about twenty seconds. Soon after, an electric spot glowed suddenly in its centre for about the same length of time. With these exceptions, it appeared steadily and uniformly illuminated. Mr. Lesley compared it with the triple curtain aurora which he saw July 23d, 1862, on the banks of the Gulf of St. Lawrence, and described in the Proceedings of the Society, Vol. IX, page 60.

Dr. Emerson called the attention of the Society to the Robbins' process for preserving wood from mould and decay by the injection of the vapors of coal tar. Professor Cresson explained the difference between this and other processes for attaining the same end; especially one now in use in Philadelphia, in which the spontaneous inflammability of wood injected with high volatile hydrocarbons is guarded against by a subsequent injection of the surface with silicates.

Nominations Nos. 622 and 626 were read and spoken to. At the request of the recommenders, nomination No. 626, after being discussed, was postponed, for the purpose of affording an opportunity for associating with it other names mentioned in the discussion. Nos. 622 to 625 were then balloted for.

The Rittenhouse Clock. The curators were authorized to have it put in complete order, although it is no longer fit to use for astronomical purposes.

The following named persons were declared duly elected members of the Society:

D. G. Brinton, M. D., of Philadelphia.

A. D. White, President Cornell University, Ithaca, N. Y.

J. H. C. Coffin, U. S. N., Supt. Naut. Almanac, Washington, D. C.

Joseph Wharton, of Philadelphia.

And the Society was adjourned.

Stated Meeting, May 7, 1869.

Present, nine members.

JOHN C. CRESSON, Vice-President, in the Chair.

Dr. Brinton was introduced to the presiding officer, and took his seat.

Letters accepting membership were received from J. H. C. Coffin, dated Nautical Almanac Office, Washington, April 21, 1869; D. G. Brinton, dated 1001 North Sixth street, Philadelphia, April 19, 1869; A. Carlier, dated 6 rue de Milan, Paris, Avril 19, 1869, and D. White, dated Cornell University, Ithaca, N. Y., May 1.

Donations for the Library were received from the Royal Academies and Societies at St. Petersburg, Berlin, Copenhagen, Göttingen, Munich, and Dublin; the Societies of Science at Offenbach, Frankfort, Bordeaux, Manchester and Leeds; the Geological Societies at Vienna, and Geographical Societies at London and Paris, the Zoological Botanical Society at Vienna, the London Astronomical, Chemical, Meteorological and Asiatic Societies, the Boston Natural Historical Society and Wool Manufacturers Association, the American Pharmaceutical Society, Academy of Natural Sciences, Franklin Institute, House of Refuge, Deaf and Dumb Institute, Dr. C. D. Meigs, the United States Sanitary Commission, the Congressional Library, and Mr. T. B. Brooks, Civil Engineer at Negaunee, Michigan.

Dr. Hayden presented, for publication in the Transactions, an Appendix to his report of the Geology on the Yellow and Missouri Rivers, under the superintendence of Captain Ray-

nolds, said Appendix consisting of a sub-report on the Carices of the Expedition made by the late Dr. Dewey. On motion, the Memoir (with its five plates) was referred to a Committee consisting of Mr. Durand, Mr. James, and Dr. Ruschenberger.

Mr. Rothwell, Engineer of Mines, exhibited through the Secretary a published copy of his new map of the eastern end of the first Anthracite Coal Basin, with cross sections, showing the excessive plication of the synclinal. (See Plate 2, fig. 2.)

Mr. Chase communicated by permission of Mr. Pierce, Director of the U. S. Coast Survey, the more recent results of his investigations into the rain gauge curves.

The observations which were examined, and the method of treatment, were described in my discussion of the tidal rain-fall of Philadelphia, (*ante*, vol. x., pp. 523-7).

The frequent tendency to triple maxima and minima, which I have attributed to lunar influence on the daily barometric spheroid,—the establishments, both of temperature, and of position with reference to great bodies of water,—the different relations of precipitation to atmospheric pressure at different seasons of the year,—the influence of the moon and of each of the principal planets on temperature, winds, cloudiness, and both frequency and amount of rain-fall,—the probability that the influences upon temperature are due to the induced aerial currents and not to radiation, (a South wind raising, and a North wind depressing the thermometer),—the secular variation, which appears to depend principally upon the combined action of the Moon and Jupiter,—are all clearly indicated by the normal curves.

Most of the curves show a great similarity at the opposite equinoxes, and a great contrast at the opposite solstices, both at Greenwich and at Philadelphia. But in the total rain-fall at different solar hours, the equinoctial and solstitial contrast is modified by a synchronous divergence at the two stations, the Philadelphia curves differing greatly at the equinoxes and being nearly alike at the solstices. This peculiarity may be owing to the fact that the prevailing winds at Greenwich are from the ocean, while those at Philadelphia are from the land, so that an atmosphere saturated with moisture is normal at the former station, abnormal at the latter.

The planetary curves are so strongly marked that it seems impossible to account for them by any action analogous to the Moon's differential attraction. They may perhaps be satisfactorily explained by the moment of inertia, and the constantly and often rapidly varying distance of the centre of gravity of the earth and disturbing planet.

Dr. Brinton communicated the information which he had obtained respecting the valuable Arawak MSS. Grammar and

Vocabulary by Shultz, in the library of this Society, and the desirableness of publishing a discussion of their relations to other MSS. existing in Europe. It appears that the language which Columbus reported to be common to all the larger islands of the W. Indies was neither Carib, nor Maya, but genuine Arawak, scarcely differing from that now spoken between the Amazon and Orinoco, not more than Chaucer's English from the English of to-day. It is an added proof that the whole fauna (man included) of the islands outside the Gulf Stream came from the Spanish Main, the movement being in the opposite direction to that of the fauna of N. America which terminated its course in Florida.

A letter and enclosed testimonial note of the proceedings of the Michaux Legacy were read, from M. Carlier, announcing the final settlement of the legacy at Paris and in Pontoise; and on motion of Mr. Chase, these documents were referred to the Committee on the Michaux Legacy with instructions to prepare the needful papers, and procure the signature of the President of this Society, and to remit funds for the expenses incurred; and they are hereby authorized to draw upon the Treasurer of the Society for the necessary amount.

A communication from the Janitor was referred to the Committee on the Hall. And the Society was adjourned.

Stated Meeting, May 21, 1869.

Present, seventeen members.

Mr. Fraley, Vice-President, in the Chair.

Mr. Wharton was introduced to the presiding officer, and took his seat.

A letter returning thanks for election to membership, was received from the President of the United States, dated Executive Mansion, April 24, 1869.

A letter acknowledging the receipt of a set of the Society's

Proceedings, Vol. I to X., was received from the London Meteorological Office, May 9th, 1869, and from the R. Academy at Lisbon, acknowledging receipt of No. 77.

Donations for the Library were reported from the Berlin Academy, Dr. Jarvis, Mr. Haven, Dr. Le Conte, Prof. Coffin, the New York Canal Commissioners, Buffalo Young Men's Association, Cincinnati Observatory, and California Academy of Sciences.

The Committee on Dr. Dewey's Carices, &c., reported, recommending its publication in the Transactions, which was so ordered.

A communication and letter was received for the Magellanic Premium, read by title and regularly referred to the Board of Officers.

Dr. Horn presented for publication in the Transactions a paper entitled Revision of the Tenebrionidæ of America north of Mexico, by Geo. H. Horn, M. D., which was referred to Dr. Le Conte, Dr. Leidy and Dr. Bridges.

Mr. Lesley exhibited a photo-lithograph of a section across the Alleghany mountains, to illustrate the proportionate plication of the earth's surface to its radius. See Plate 2, Fig. 1.

Dr. Hayden's Geological Map of the Upper Missouri was exhibited, together with many sketches and photographs of scenery and structure. It was afterwards resolved, that the Secretaries be instructed to address a letter to Gen'l A. A. Humphreys, Chief Engineer U S. A., expressing the desire of the A. P. S. to have the results of the Geological explorations made in the Territories of the U. S. by Dr. Newberry, Hayden and others, while employed by the Government, made speedily available for present use by publication at the expense of the Government, or in such other manner as may be thought expedient.

The Committee to which was referred the publication of the Choltec MS. recommended its publication in the Proceedings, under the supervision of Dr. Brinton, which was so ordered, and on motion of Mr. Price, the Secretaries were authorized to print additional copies, according to their best judgment.

And the Society was adjourned.

Stated Meeting, June 18, 1869.

Present, ten members.

Mr. FRALEY, Vice-President, in the Chair.

A letter accepting membership was received from Professor Rolliston, University Oxford, England. May 29.

Letters of invoice were received from the Imperial Geog. Society of Russia, May 15; U. S. Nav. Obs. May 19th; Cincinnati Obs. May; and A. M. Mayer, of Bethlehem, May 26.

Letters of acknowledgment were received from the Imperial Geographical Society of Russia. The Cincinnati Observatory requested the completion of its imperfect set of the Proceedings.

The Meteorological Office reported its change of address to No. 116 Victoria street, London, S. W.

Donations for the Library were received from the Paris Geographical Society and School of Mines, the London Astronomical Society, Prof. Rolliston, of Oxford, the Bath Society, W. T. Blanford, the Boston N. H. Society, the Rhode Island Society for En. Dom. Industry, Franklin Institute, College of Pharmacy, Medical News, Philadelphia University, West Penn Academy, Prof. Mayer, Prof. Ennis, Provost C. J. Stille, the U. S. Sanitory Commission, Naval Observatory, Census Bureau, R. W. Rossiter, Wilmington Institute, and St. Louis Public School Commissioners.

Mr. Cope made a communication concerning a discovery of certain fossil remains found in New Jersey, the structure of which indicated a connection between the bird and reptile classes, and described the peculiarities of construction presented by the fossil referred to. He also exhibited fossil remains of the Plesiosaurus and Mososaurus orders or types, and described their relation to other genera of similar type.

The fossil which Prof. Cope exhibited was the almost perfect cranium of a Mosasauroid reptile, the Clidastes propython. He explained various peculiarities of its structure, as the moveable articulation of certain of the mandibular pieces on each other, the suspension of the os-quadratum at the extremity of a cylinder composed of the opisthotic, &c., and other peculiarities. He also explained, from specimens, the characters of a large new Plesiosauroid from Kansas, discovered by Wm. E. Webb, of Topeka, which possessed deeply biconcave vertebrae, and anchylosed veural arches, with the zygapophyses directed after the manner usual among vertebrates. The former was thus shown to belong to the true Sauropterygia, and not to the Streptosauria, of which Elasmosarus was type. Several distal caudals were anchylosed, without chevron bones, and of depressed form, while proximal caudals had anchylosed diapophyses and distinct chevron bones. The form was regarded as new, and called Polycotylus latipinnis, from the great relative stoutness of the paddle.

He also gave an account of the discovery, by Dr. Samuel Lockwood, of Keyport, of a fragment of a large Dinasaur, in the clay which underlies immediately the clay marls below the lower green sand bed in Monmouth County, N. J. The piece was the extremities of the tibia and fibula, with astragalo-calcaneum anchylosed to the former, in length about sixteen inches; distal width fourteen. The confluence of the first series of tarsal bones with each other, and with the tibia, he regarded as a most interesting peculiarity, and one only met with elsewhere in the reptile Compsognathus and in birds. He therefore referred the animal to the order Symphypoda, near to Compsognathus Wagn. The extremity of the fibula was free from, and received into a cavity of the astragalo-calcaneum, and demonstrated what the speaker had already asserted, that the fibula of Ignanodon and Hadrosaurus had been inverted by their describers. The medullary cavity was filled with open cancellous tissue. The species, which was one half larger than the type specimen of Hadrosaurus foulkii, he named Ornithotarsus immanis.

Dr. H. C. Wood spoke of his investigations with regard to the Fresh Water Algæ of Eastern North America.

Pending nominations, Nos. 628 to 638, new nominations, Nos. 638 to 640, were read.

Dr. H. Allen offered and read a paper "On Human Osteology, containing the heads of divisions of a more extended communication, which he proposes to present at a future time.

The following observations have been instituted with the object of testing the value of the following propositions:

I.

That a true conception of the skeleton can be only secured by studying embryology and osteology conjointly.

For inasmuch as the skeleton is the frame-work adapted to protect internal organs, and to afford attachments to ligaments and muscles, and since the osseous particles (centres of ossification, either free or combined) are the results of forces acting in obedience to the necessities of organs to be protected and of trunks to be moved, it follows that bones can be best studied when understanding the requirements calling them into existence.

II.

That the "centre of ossification" is the osteological unit.

For since "the bones" are associations of centres of ossification having little or no determinate value, it is rational to prefer these centres as the primal forms, before the more or less arbitrary ones, the results of their combination.

III.

That the causes of variation of the forms of "bones" within the limits of health are to be found in the muscles placed in association with them.

Since the idea of a limb is progression, the bones stand up as fulcra and levers to the power, we find the degree of power holds a direct ratio to the strength of lever and amount of weight. Hence, bones of limbs correspond in point of strength and size to the muscles associated with them. Habit is thus seen to be indirectly the chief cause of the variation of ossific forms.

IV.

That the causes of localization of diseased action are best determined by the application of the foregoing propositions.

(1.) A number of centres of ossification coalescing to protect a given viscus, the resultant form may preserve, throughout life, a physiological as well as a mechanical unity. Example: The centres composing the brain case. When, however, the centres of ossification in the bones of limbs unite, while losing their identity in form they maintain a peculiar independence of action throughout life. Example: The centre composing the femur and tibia.

(2.) The evidences of retrograde activity (atrophy) are most marked along the lines of progressive activity (growth.)

(3.) Activity of development is accompanied with vascularity. Increased vascularity is an exciting cause to morbid action. Therefore it follows that diseased action may be often found in association with an incomplete genetic process.

(4.) Since muscles control the normal shapes of bones during harmonious action, their inharmonious action may prove a cause of deformity.

(5.) Continual excitation of points of connection of muscles with bones may prove an exciting cause to disease within such areas.

The Society was then adjourned.

J. P. LESLEY 1869. PHILADELPHIA.

FIG. 1. SECTION OF 150 MILES ACROSS THE APPALACHIAN BELT IN PENSYLVANIA

DRAWN TO THE SAME SCALE VERTICAL AND HORIZONTAL.

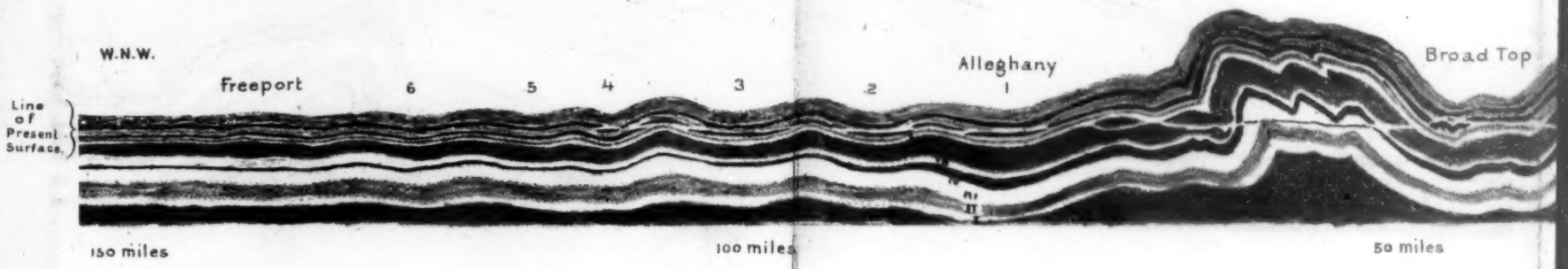


FIG. 2.

LEHIGH COAL & NAVIGATION CO'S COAL PROPERTY.

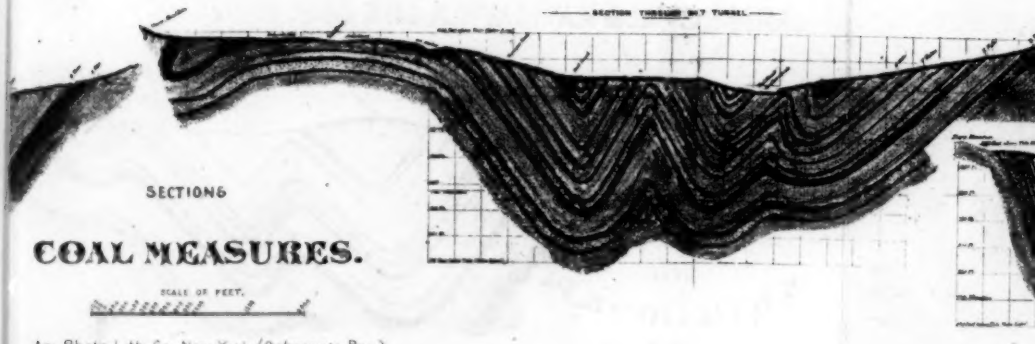
Am. Photo-Lith. Co. New York (Osborne's Pro.)

ECTION OF 150 MILES ACROSS THE APPALACHIAN BELT IN PENSYLVANIA

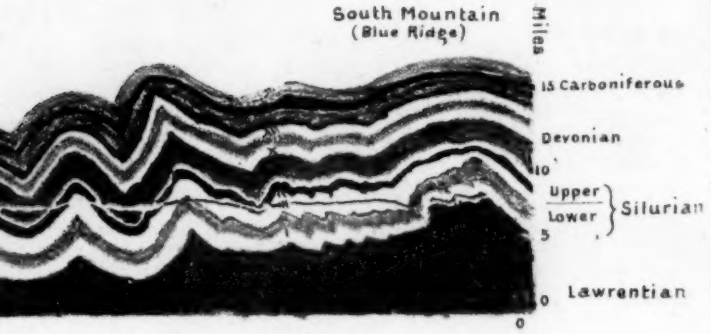
DRAWN TO THE SAME SCALE VERTICAL AND HORIZONTAL.

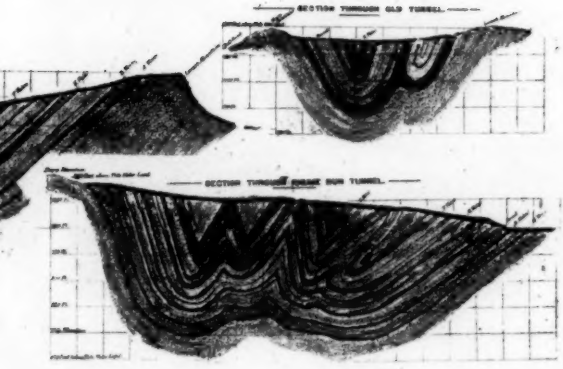
50 miles

FIG.2.



Am. Photo-Lith. Co. New York (Osborne's Pro.)


South Mountain
(Blue Ridge)
Miles
15
Carboniferous
Devonian
10
Upper
Lower
Silurian
5
0
Lawrentian
0



At page 377 of the IX Vol. of the Proceedings of the American Philosophical Society will be found a Catalogue of books which belonged to the late Major LeConte. These are now offered to the Society at a valuation to be fixed by itself. The Society desires to know the true value of them, and whether the University or Institution to which this notice is hereby addressed, wishes itself to become the purchaser of them. It is proper that these books should go where they will be most useful, and that will be where Oriental Literature is most cultivated. The books are well bound and in good condition. Your early answer is respectfully requested.

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